

Pre-Hearing Draft

The Kentucky 8-Hour Ozone Attainment Demonstration for the Cincinnati-Hamilton, OH-KY-IN 8-Hour Ozone Nonattainment Area



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Submitted by
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PREFACE

This document contains Kentucky's modeling demonstration that the Cincinnati-Hamilton OH-KY-IN 8-hour Ozone nonattainment area will attain the National Ambient Air Quality Standard for 8-hour ozone by June 15, 2009. This area includes the entire counties of Boone, Campbell, and Kenton, counties, Kentucky, Butler, Clermont, Clinton, Hamilton, and Warren counties, Ohio, and a portion of Dearborn County, Indiana.

EXECUTIVE SUMMARY

INTRODUCTION

Ozone, a strong chemical oxidant, adversely impacts human health through effects on respiratory function and can also damage forests and crops. Ozone is not emitted directly by the utilities, industrial sources or motor vehicles but instead, is formed in the lower atmosphere, the troposphere, by a complex series of chemical reactions involving nitrogen oxides (NO_x), resulting from the utilities, combustion processes and motor vehicles, and reactive volatile organic compounds (VOCs). VOCs include many industrial solvents, such as toluene, xylene and hexane as well as the various hydrocarbons (HC) that are evaporated from the gasoline used by motor vehicles or emitted through the tailpipe following combustion. Additionally, VOCs are emitted by natural sources such as trees and crops.

Ozone formation is promoted by strong sunlight, warm temperatures and light winds. High concentrations tend to be a problem in the eastern United States only during the hot summer months when these conditions frequently occur. Therefore, the U. S. Environmental Protection Agency (USEPA) mandates seasonal monitoring of ambient ozone concentrations in Kentucky from March 1 through October 31 (40 CFR 58 App. D, 2.5).

NATIONAL AMBIENT AIR QUALITY STANDARD (NAAQS)

The USEPA promulgated a new 8-hour ozone NAAQS in July 1997, setting the standard at 0.08 parts per million (ppm) averaged over an 8-hour period. An exceedance of the 8-hour ozone NAAQS occurs when a monitor measures ozone above 0.084 ppm (per the rounding convention). A violation of the NAAQS occurs when the average of the annual fourth highest daily maximum 8-hour ozone values over three consecutive years is equal to or greater than 0.085 ppm. This three-year average is termed the design value for the monitor. The design value for a nonattainment area is the highest monitor's design value in the area.

NATURE OF PROBLEM IN KENTUCKY

In April 2004, the USEPA designated areas as nonattainment for the 8-hour ozone NAAQS based upon air quality monitoring data measured during the 2001, 2002 and 2003 ozone seasons. These designations became effective on June 15, 2004. In Kentucky there were four areas designated as nonattainment (see Figure 1).

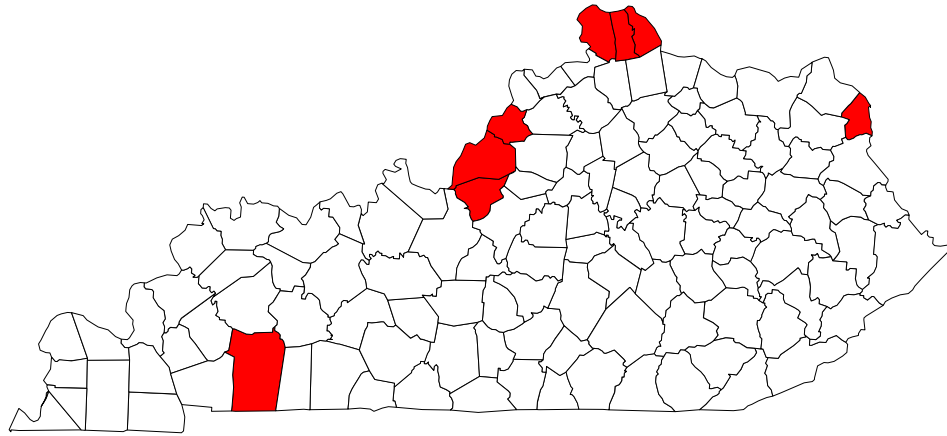


Figure 1. 8-hour Ozone Nonattainment Boundaries for Kentucky

This submittal covers the Kentucky portion of the Cincinnati-Hamilton OH-KY-IN 8-hour ozone nonattainment area. This area was designated as basic nonattainment under subpart 1 since the area's 1-hour ozone design value was 0.118 ppm. Areas with 1-hour design values at less than 0.121 ppm were designated under subpart 1, since this threshold was the low end of the classification table in Section 181(a)(1) of the Clean Air Act. The USEPA determined during the designation process that this was the appropriate treatment of the classification table under the 8-hour standard. This nonattainment area includes the entire counties of Boone, Campbell, and Kenton in Kentucky, Butler, Clermont, Clinton, Hamilton, and Warren in Ohio, and a portion of Dearborn in Indiana.

CONTROLS APPLIED

Several control measures already in place or being implemented over the next few years will reduce stationary point, highway mobile, and nonroad mobile sources emissions. The expected Federal and State control measures were modeled for the attainment year of 2009.

The Federal control measures that were modeled included the Tier 2 vehicle standards; the heavy-duty gasoline and diesel highway vehicle standards; low sulfur gasoline and diesel fuels, large nonroad diesel engines standards; the nonroad spark-ignition engines and recreational engines standard; and the Clean Air Interstate Rule.

The State control measure that was modeled is the NO_x SIP Call Rule, which will reduce summertime NO_x emissions from power plants and other industries.

ATTAINMENT TEST RESULTS

The attainment test is not based on absolute modeling results, but rather relative reductions of ozone and is only applied at grid cells near the monitors. However, reviewing the modeling results of how the predicted ozone decreases in the future years and how wide spread the reductions are play an important role for the State in determining if additional controls should be considered.

The air quality modeling is used in a relative sense by determining what the relative reduction in ozone occurred between the baseline year (2002) and the attainment year (2009). Table 1 lists the attainment test results for the Cincinnati-Hamilton OH-KY-IN area. The first two columns are the monitoring site and the county in which the site is located. The next three columns are the modeling base year design value (DVB), the relative response factor (RRF) and the future design value (DVF). According to the USEPA's guidance, areas with future design values between 0.082 and 0.087 ppm need to provide additional weight of evidence that the area will attain the 8-hour ozone NAAQS. Four of the monitors in the Cincinnati-Hamilton OH-KY-IN area fall within the range requiring additional weight of evidence to demonstrate attainment.

Table 1 Attainment Test Results

County	Monitor I.D.	DVB 5-Year Straight Average 2000-2004 (ppm)	RRF	DVF (ppm)
Boone	21-015-0003	0.0816	0.870	0.071
Campbell	21-037-0003*	0.0888	0.908	0.080
Kenton	21-117-0007	0.0834	0.908	0.075
Butler	39-017-0004	0.0868	0.905	0.078
Butler	39-017-1004	0.0856	0.897	0.076
Clermont	39-025-0022	0.0874	0.907	0.079
Hamilton	39-061-0006	0.0876	0.898	0.078
Hamilton	39-061-0010	0.0836	0.905	0.075
Hamilton	39-061-0040	0.0844	0.918	0.077
Warren	39-165-0006**	0.0880	0.878	0.077
Warren	39-165-0007	0.0880	0.878	0.077

* This monitor was discontinued after the 2005 ozone season.

**This monitor was discontinued after the 2003 ozone season and became 0007 in 2004.

The Kentucky Division for Air Quality (KYDAQ) provided strong weight of evidence that the Cincinnati-Hamilton OH-KY-IN nonattainment area will attain the 8-hour ozone NAAQS by 2008. These included looking at alternative methods to calculate the future design values, current air quality data and the emission reductions still to occur in 2007, 2008 and 2009, and additional measures that were not included in the air quality modeling.

The KYDAQ believes that the modeling attainment demonstration, in conjunction with the weight of evidence analyses, provides the necessary evidence that the Cincinnati-Hamilton OH-KY-IN nonattainment area will attain the NAAQS by the prescribed attainment date.

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1.0 INTRODUCTION

1.1 What is tropospheric ozone?

Ozone, a strong chemical oxidant, adversely impacts human health through effects on respiratory function and can also damage forests and crops. Ozone is not emitted directly by utilities, industrial sources or motor vehicles but instead, is formed in the lower atmosphere, the troposphere, by a complex series of chemical reactions involving nitrogen oxides (NO_x), resulting from the utilities, combustion processes and motor vehicles, and reactive volatile organic compounds (VOCs). VOCs include many industrial solvents, such as toluene, xylene and hexane as well as the various hydrocarbons (HC) that are evaporated from the gasoline used by motor vehicles or emitted through the tailpipe following combustion. Additionally, VOCs are emitted by natural sources such as trees and crops.

Ozone formation is promoted by strong sunlight, warm temperatures and light winds. High concentrations tend to be a problem in the eastern United States only during the hot summer months when these conditions frequently occur. Therefore, the U. S. Environmental Protection Agency (USEPA) mandates seasonal monitoring of ambient ozone concentrations in Kentucky from March 1 through October 31 (40 CFR 58 App. D, 2.5).

1.2 What is the National Ambient Air Quality Standard?

In 1997 the USEPA revised the primary (health) and secondary (welfare) national ambient air quality standard (NAAQS) for ground-level ozone (40 CFR 50.9), setting the standard at 0.08 parts per million (ppm) averaged over an 8-hour period. The USEPA was sued on this action and in May 1999 the U. S. Court of Appeals for the D. C. Circuit remanded the 8-hour ozone standard back to the USEPA. In 2001, the USEPA proposed a response to the remand and reaffirmed the standard. Finally, in 2003 the 8-hour ozone standard became effective. The USEPA made nonattainment designations for the 8-hour ozone standard on April 30, 2004 with an effective date of June 15, 2004.

An exceedance of the 8-hour ozone NAAQS occurs when a monitor measures ozone above 0.084 ppm (per the rounding convention) over an 8-hour period. A violation of the NAAQS occurs when the average of the annual fourth highest daily maximum 8-hour ozone values over three consecutive years is greater than or equal to 0.085 ppm. This three-year average is termed the design value for the monitor. The design value for a nonattainment area is the highest monitor's design value in the area.

Since the 1977 amendments to the Clean Air Act (CAA), areas of the country that violated the ambient standard for a particular pollutant were formally designated as nonattainment for that pollutant. This formal designation concept was retained in the 1990 Amendments (CAAA), but additionally, areas designated as nonattainment for the 1-hour ozone standard were to be classified as to the degree of nonattainment. Five categories were created (section 181 of the 1990 CAAA). In increasing severity, these were marginal, moderate, serious, severe and extreme. The attainment dates for these areas were based upon this classification. The highest monitor design value in a nonattainment area was used to determine its classification.

With the implementation of the 8-hour ozone standard, an area could be designated under section 172 of the 1990 CAAA (subpart 1) as “basic” and would have 5 years from designation to attain the standard or could be designated under section 181 (subpart 2) and classified as one of the five categories with attainment dates based on the classification. Areas with an 1-hour ozone design value greater than 0.121 ppm were classified under subpart 2 and all other areas were classified under subpart 1. The Cincinnati-Hamilton OH-KY-IN area had a 1-hour design value of 0.118 and therefore was classified as basic nonattainment.

1.3 Nature of Problem in Kentucky

On April 15, 2004, the USEPA designated areas as nonattainment for the 8-hour ozone NAAQS based upon air quality monitoring data measured during the 2001, 2002 and 2003 ozone seasons. These designations became effective on June 15, 2004. In Kentucky, there were four areas designated as nonattainment: the Clarksville-Hopkinsville, TN-KY 8-Hour Nonattainment area which consists of Christian County, Kentucky and Montgomery County, Tennessee, the Louisville, KY-IN 8-Hour Nonattainment area, which consists of Bullitt, Oldham, and Jefferson Counties, Kentucky and Clark and Floyd Counties, Indiana, the Ashland-Huntington, KY-WV 8-Hour Nonattainment area which consists of Boyd County, Kentucky, and Wayne and Cabell Counties, West Virginia, and the Cincinnati-Hamilton OH-KY-IN 8-Hour Nonattainment area which consists of Boone, Campbell, and Kenton counties in Kentucky, Butler, Clermont, Clinton, Hamilton, and Warren counties in Ohio, and a portion of Dearborn County, Indiana..

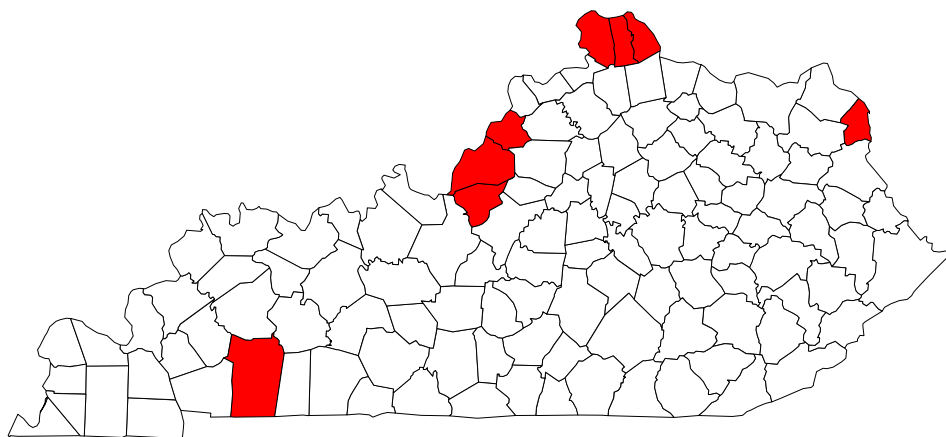


Figure 1.3-1 8-hour ozone nonattainment boundaries for Kentucky

The Cincinnati-Hamilton OH-KY-IN 8-hour ozone nonattainment area was designated under subpart 1 since that area’s 1-hour ozone design value was below 0.121 ppm. Figure 1.3-2 displays where the monitors are located in the Cincinnati-Hamilton OH-KY-IN nonattainment area. The air quality data on which the designations were based is listed in Table 1.3-1. This table includes all of the monitors within the Cincinnati-Hamilton OH-KY-IN nonattainment area. The historic air quality data for the monitors in the Cincinnati-Hamilton OH-KY-IN nonattainment area is listed in Appendix B.

Figure 1.3-2 Monitor locations in the nonattainment area

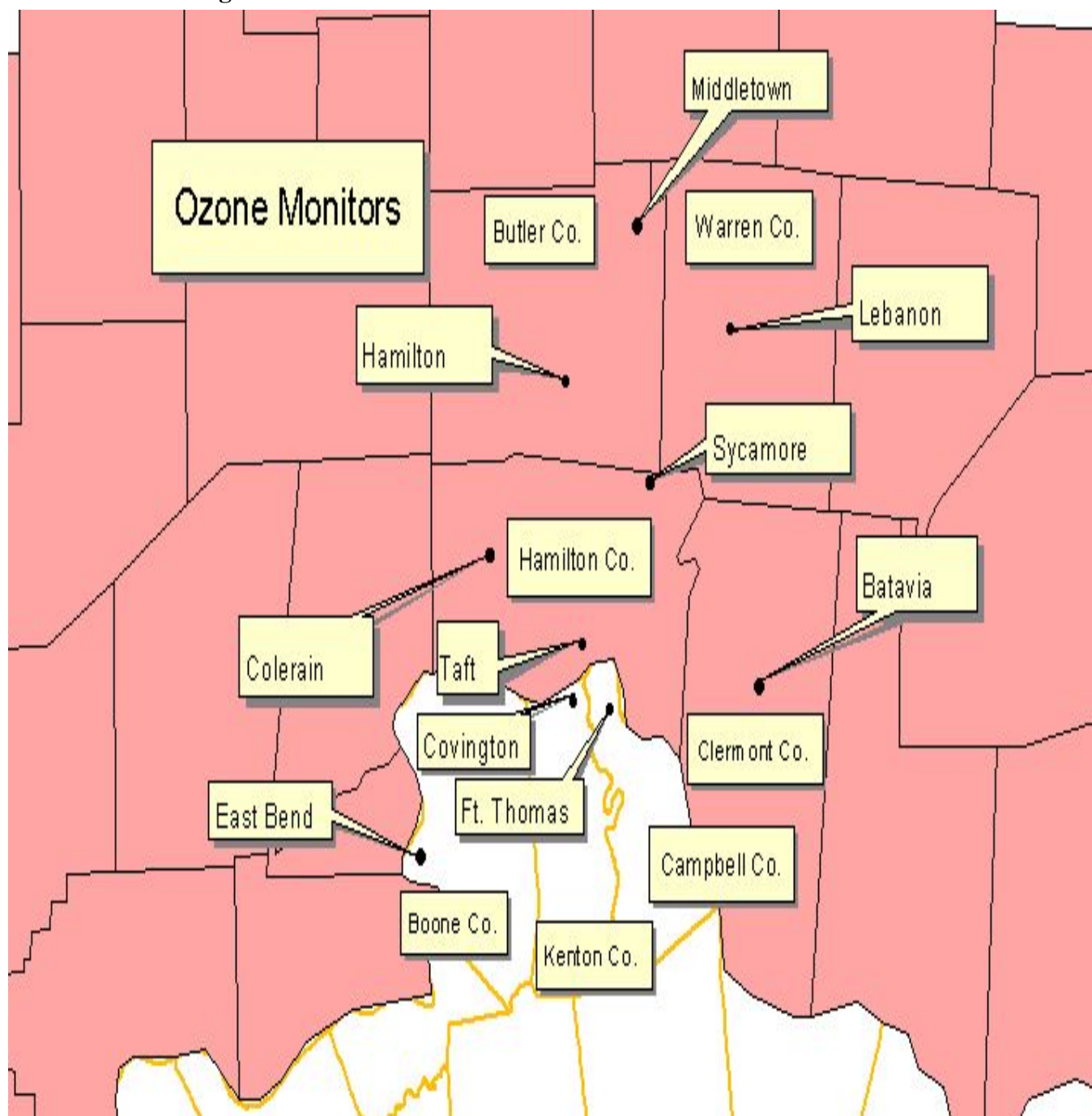


Table 1.3-1 Northern Kentucky area Air Quality Data Designations were Based Upon

Monitor	County, State	4 th Highest 8-hour Ozone Value			2001-2003 Design Value
		2001	2002	2003	
Boone	Boone Co., KY	0.083	0.094	0.078	0.085
Campbell	Campbell Co., KY	0.088	0.102	0.085	0.091
Kenton	Kenton Co., KY	0.082	0.096	0.079	0.085
Ohio					
Hamilton	Butler Co., OH	0.083	0.100	0.094	0.092
Middletown	Butler Co., OH	0.087	0.098	0.083	0.089
Batavia	Clermont Co., OH	0.083	0.098	0.090	0.090
Sycamore	Hamilton Co., OH	0.088	0.100	0.093	0.093
Colerain	Hamilton Co., OH	0.080	0.096	0.087	0.087
Taft	Hamilton Co., OH	0.083	.095	0.083	0.087
Lebanon	Warren Co., OH	0.085	.098	0.090	0.091

Bolded values represent violations of the 8-hour ozone NAAQS.

1.4 Clean Air Act Requirements

Sections 172(c), 182(a) and 182 (b) of the CAA, as amended, contain the requirements for ozone nonattainment areas. As a subpart 1 nonattainment area, the Cincinnati-Hamilton OH-KY-IN area must meet the general requirements contained in Section 172(c). These requirements are listed below and are discussed in more detail in Section 6.

Section 172(c) Nonattainment Plan Provisions

- (1) Reasonable available control measures (RACM)
- (2) Reasonable further progress (RFP)
- (3) Actual emissions inventory and periodic emissions inventory
- (4) New source review (NSR)
- (5) Permit requirements for new and modified sources
- (6) Other measures as may be necessary to provide attainment by specified attainment date
- (7) Compliance with Section 110(a)(2)
- (8) Contingency measures

2.0 ATTAINMENT DEMONSTRATION METHODS AND INPUTS

The attainment modeling for the Cincinnati-Hamilton OH-KY-IN 8-hour nonattainment area was performed in conjunction with the regional haze modeling being done by the Southeast Regional Planning Organization, Visibility Improvement State and Tribal Association of the Southeast (VISTAS) and the fine particulate matter (PM_{2.5}) and ozone modeling being done by the Association of Southeastern Integrated Planning (ASIP). VISTAS and ASIP are run by the ten Southeast states (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia and West Virginia). Since the regional haze and PM_{2.5} modeling uses annual simulations and includes an intermediate year that is the attainment year required for the Cincinnati-Hamilton OH-KY-IN 8-hour Ozone Nonattainment Area nonattainment area, the Kentucky Division for Air Quality (KYDAQ) decided to use this modeling for the required attainment demonstration. The sections below outline the methods and inputs used by VISTAS/ASIP for the regional modeling. The Ohio and Indiana portion of the nonattainment area utilizes modeling done by the Lake Michigan Air Directors Consortium (LADCO), and both states are using a 2005 base year inventory. Documentation of LADCO modeling is in Appendix M.

2.1 Analysis Method

The modeling analysis is a complex technical evaluation that begins by selection of the modeling system. VISTAS decided to use the following modeling system:

- **Meteorological Model:** The Pennsylvania State University/National Center for Atmospheric Research (PSU/NCAR) Mesoscale Meteorological Model (MM5) is a nonhydrostatic, prognostic meteorological model routinely used for urban- and regional-scale photochemical, fine particulate matter, and regional haze regulatory modeling studies.
- **Emissions Model:** The Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system is an emissions modeling system that generates hourly gridded speciated emission inputs of mobile, nonroad mobile, area, point, fire and biogenic emission sources for photochemical grid models.
- **Air Quality Model:** USEPA's Models-3/ Community Multiscale Air Quality (CMAQ) modeling system is a 'One-Atmosphere' photochemical grid model capable of addressing ozone, particulate matter (PM), visibility and acid deposition at regional scale for periods up to one year.

Additionally, an historic year is selected to model that represents typical meteorological conditions in the Southeast when high ozone, PM_{2.5} and poor visibility are observed throughout the Region. Once the historic year is selected, meteorological inputs are developed using the meteorological model. Emission inventories are also developed for the historic year and processed through the emissions model. These inputs are used in the air quality model to predict ozone, PM_{2.5} and visibility, with the results compared to the historic data. The model performance is evaluated by comparing the modeled predicted data to the historic air quality data.

Once model performance is deemed adequate, typical baseline and future year emissions are processed through the emissions model. For this demonstration, the baseline year was 2002, which corresponds with the same year as the historic meteorology used in the modeling. The attainment future year KYDAQ is using for this demonstration is 2008, since mandatory attainment date for the Cincinnati-Hamilton OH-KY-IN 8-hour Ozone Nonattainment Area is June 15, 2009. The attainment date is set prior to the completion of the 2009 ozone season, therefore the attainment of the NAAQS would have to be met by the end of the 2008 ozone season. These 2009 emissions are processed through the air quality model with the meteorological inputs. The air quality modeling results are used to determine a relative reduction in future ozone, which is used in the 2008 attainment demonstration.

In May 2006, U.S. EPA indicated approval of the use of 2008 inventories, and 2009 emissions and air quality modeling with weight of evidence to be used in the 2008 attainment demonstration (see email from Brenda Johnson dated May 9th, 2006, in Appendix A). Both 2008, as well as 2009, emissions data will be included in this submittal. The complete modeling protocol used for this analysis can be found in Appendix C.

2.2 Model Selection

To ensure that a modeling study is defensible, care must be taken in the selection of the models to be used. The models selected must be scientifically appropriate for the intended application and be freely accessible to all stakeholders. Scientifically appropriate means that the models address important physical and chemical phenomena in sufficient detail, using peer-reviewed methods. Freely accessible means that model formulations and coding are freely available for review and that the models are available to stakeholders, and their consultants, for execution and verification at no or low cost.

The following sections outline the criteria for selecting a modeling system that is both defensible and capable of meeting the study's goals. These criteria were used in selecting the modeling system used for this modeling attainment demonstration.

2.2.1 Selection of Photochemical Grid Model

Criteria

For a photochemical grid model to qualify as a candidate for use in an attainment demonstration of the 8-hour ozone NAAQS, a State needs to show that it meets several general criteria:

- The model has received a scientific peer review
- The model can be demonstrated applicable to the problem on a theoretical basis
- Data bases needed to perform the analysis are available and adequate
- Available past appropriate performance evaluations have shown the model is not biased toward underestimates or overestimates
- A protocol on methods and procedures to be followed has been established

- The developer of the model must be willing to make the source code available to users for free or for a reasonable cost, and the model cannot otherwise be proprietary.

Overview of CMAQ

The photochemical model selected for this study was CMAQ version 4.4. For more than a decade, the USEPA has been developing the Models-3 CMAQ modeling system with the overarching aim of producing a ‘One-Atmosphere’ air quality modeling system capable of addressing ozone, fine particulate matter, visibility and acid deposition within a common platform. The original justification for the Models-3 development emerged from the challenges posed by the 1990 CAAA and the USEPA’s desire to develop an advanced modeling framework for ‘holistic’ environmental modeling utilizing state-of-science representations of atmospheric processes in a high performance computing environment. The USEPA completed the initial stage of development with Models-3 and released the CMAQ model in mid 1999 as the initial operating science model under the Models-3 framework. The most recent rendition is CMAQ version 4.4, which was released in October 2004.

Another reason for choosing CMAQ as the atmospheric model is the ability to do one-atmospheric modeling. Since KYDAQ will be using the same modeling exercise for the ozone and PM_{2.5} attainment demonstrations SIPs, as well as the regional haze SIP, having a model that can handle both ozone and particulate matter is essential. A number of features in CMAQ’s theoretical formulation and technical implementation make the model well suited for annual PM modeling.

The configuration used for this modeling demonstration, as well as a more detailed description of the CMAQ model, can be found in the Modeling Protocol (Appendix C).

2.2.2 Selection of Meteorological Model

Criteria

Meteorological models, either through objective, diagnostic, or prognostic analysis, extend available information about the state of the atmosphere to the grid upon which photochemical grid modeling is to be carried out. The criteria for selecting a meteorological model are based on both the models ability to accurately replicate important meteorological phenomena in the region of study, and the model's ability to interface with the rest of the modeling systems -- particularly the photochemical grid model. With these issues in mind, the following criteria were established for the meteorological model to be used in this study:

- Non-Hydrostatic Formulation
- Reasonably current, peer reviewed formulation
- Simulates Cloud Physics
- Publicly available on no or low cost
- Output available in I/O API format

- Supports Four Dimensional Data Assimilation (FDDA)
- Enhanced treatment of Planetary Boundary Layer heights for AQ modeling

Overview of MM5

The non-hydrostatic MM5 model is a three-dimensional, limited-area, primitive equation, prognostic model that has been used widely in regional air quality model applications. The basic model has been under continuous development, improvement, testing and open peer-review for more than 20 years and has been used worldwide by hundreds of scientists for a variety of mesoscale studies.

MM5 uses a terrain-following non-dimensionalized pressure, or "sigma", vertical coordinate similar to that used in many operational and research models. In the non-hydrostatic MM5, the sigma levels are defined according to the initial hydrostatically-balanced reference state so that the sigma levels are also time-invariant. The gridded meteorological fields produced by MM5 are directly compatible with the input requirements of 'one atmosphere' air-quality models using this coordinate. MM5 fields can be easily used in other regional air quality models with different coordinate systems by performing a vertical interpolation, followed by a mass-conservation re-adjustment.

Distinct planetary boundary layer (PBL) parameterizations are available for air-quality applications, both of which represent sub-grid-scale turbulent fluxes of heat, moisture and momentum. One scheme uses a first-order eddy diffusivity formulation for stable and neutral environments and a modified first-order scheme for unstable regimes. The other scheme uses a prognostic equation for the second-order turbulent kinetic energy, while diagnosing the other key boundary layer terms.

Initial and lateral boundary conditions are specified for real-data cases from mesoscale three-dimensional analyses performed at 12-hour intervals on the outermost grid mesh selected by the user. Surface fields are analyzed at three-hour intervals. A Cressman-based technique is used to analyze standard surface and radiosonde observations, using the National Meteorological Center's spectral analysis, as a first guess. The lateral boundary data are introduced using a relaxation technique applied in the outermost five rows and columns of the coarsest grid domain.

Results of detailed performance evaluations of the MM5 modeling system in regulatory air quality application studies have been widely reported in the literature (e.g., Emery et al., 1999; Tesche et al., 2000, 2003) and many have involved comparisons with other prognostic models such as the Regional Atmospheric Modeling System (RAMS) and the Systems Application International Mesoscale Model. The MM5 enjoys a far richer application history in regulatory modeling studies compared with RAMS or other models. Furthermore, in evaluations of these models in over 60 recent regional scale air quality application studies since 1995, it has generally been found that the MM5 model tends to produce somewhat better photochemical model inputs than alternative models.

The configuration used for this modeling demonstration, as well as a more detailed description of the MM5 model, can be found in the Modeling Protocol (Appendix C).

2.2.3 Selection of Emissions Processing System

Criteria

The principal criterion for an emissions processing system is that it accurately prepares emissions files in a format suitable for the photochemical grid model being used. The following list includes clarification of this criterion and additional desirable criteria for effective use of the system.

- File System Compatibility with the I/O API
- File Portability
- Ability to grid emissions on a Lambert Conformal projection
- Report Capability
- Graphical Analysis Capability
- MOBILE6 Mobile Source Emissions
- Biogenic Emissions Inventory System version 2 (BEIS-3)
- Ability to process emissions for the proposed domain in a reasonable amount of time.
- Ability to process control strategies
- No or low cost for acquisition and maintenance
- Expandable to support other species and mechanisms

Overview of SMOKE

The SMOKE Emissions Processing System Prototype was originally developed at the Micro-computing Center of North Carolina. As with most ‘emissions models’, SMOKE is principally an *emission processing system* and not a true *emissions modeling system* in which emissions estimates are simulated from ‘first principles’. This means that, with the exception of mobile and biogenic sources, its purpose is to provide an efficient, modern tool for converting emissions inventory data into the formatted emission files required by an air quality simulation model. For mobile sources, SMOKE actually simulates emissions rates based on input mobile-source activity data, emission factors and outputs from transportation travel-demand models.

SMOKE was originally designed to allow emissions data processing methods to utilize emergent high-performance-computing as applied to sparse-matrix algorithms. Indeed, SMOKE is the fastest emissions processing tool currently available to the air quality modeling community. The sparse matrix approach utilized throughout SMOKE permits both rapid and flexible processing of emissions data. The processing is rapid because SMOKE utilizes a series of matrix calculations instead of less efficient algorithms used in previous systems. The processing is flexible because the processing steps of temporal projection, controls, chemical speciation,

temporal allocation, and spatial allocation have been separated into independent operations wherever possible. The results from these steps are merged together at a final stage of processing.

SMOKE contains a number of major features that make it an attractive component of the modeling system. The model supports a variety of input formats from other emissions processing systems and models. It supports both gridded and county total land use scheme for biogenic emissions modeling. SMOKE can accommodate emissions files from up to 10 countries and any pollutant can be processed by the system.

For additional information about the SMOKE model please refer to Modeling Protocol (Appendix C).

2.3 Episode Selection

A crucial step to SIP modeling is the selection of episodes to model. Several considerations need to be weighed before settling on not only which days to model, but how many days for each episode. This section details the guidance and process by which episodes were selected for the 8-hour Ozone SIP modeling package.

2.3.1 Overview of USEPA Guidance on Ozone

The U.S. EPA's guidance on 8-hour ozone modeling sets out specific criteria for the selection of episodes to model for attainment of the 8-hour ozone NAAQS. First, episodes should include days encompassing a variety of meteorological conditions, including varying wind directions, for days exceeding 0.084 ppm. Additionally, episodes should be selected that contain days close (within ± 0.010 ppm) to the current design value (DVC). Episodes should also be chosen around days for which there are extensive air quality and meteorology measurements, including measurements aloft, measurements of indicator species and/or precursor measurements. Finally, a sufficient number of days should be selected to ensure robust attainment tests at violating monitoring sites.

In addition to these primary criteria, the USEPA also suggests a set of secondary criteria that may be used in the selection of episodes. This set of criteria allows states to give preference to previously modeled episodes. This is a very valuable consideration, as the USEPA points out, since it can save modeling resources and effort. Additional considerations include selecting episodes maximizing the number of days and sites observing a violation, selecting episodes which include weekends, and the selection of episodes meeting primary and secondary criteria in other nonattainment areas, when participating in regional modeling. Using these criteria laid out by the USEPA, the data available was systematically examined to determine the best episodes for modeling.

2.3.2 Episode Selection

With the advances in computing and storage technologies, and aided by regional modeling efforts, KYDAQ has moved toward the modeling of the peak ozone season for the 8-hour ozone

attainment demonstration SIP. By modeling the peak season, several criteria are covered, including the modeling of weekends and a sufficient number of days that ensures a robust modeled attainment test. Modeling the peak ozone season also accomplishes the goal of encompassing a myriad of meteorological conditions that influence ozone concentrations.

Efforts were made to determine an appropriate period to model. The selection process started with an examination of the 8-hour ozone maxima for the 1997 through 2004 seasons to determine which season may yield the most days to be included for study. Following the second primary criteria, the number of days each monitoring site observed a value within 0.010 ppm of the design value was tabulated using the recently suggested 5 year average (the 3 year average design value).

It was found that, overall, 2002 had the most days within 0.010 ppm of the design values, and generally had the most exceedance days for the individual monitoring sites. When 2002 was not the highest year, it was generally either the second or third highest, for either design value convention. Since 2002 was the base year for the VISTAS modeling as well, choosing the 2002 ozone season for the episode allowed the KYDAQ and the other States involved in ASIP to use the VISTAS modeling for the attainment demonstration for ozone.

The months of May through September 2002 were typical of the meteorology one would expect for an active ozone season, namely warmer and drier than average. Temperatures were 1-3 °F warmer than average across the state and throughout the Mid-Atlantic States and the precipitation values were 2-3 inches below normal for most of Kentucky. The dry conditions were also present for much of the coastal Mid-Atlantic States. The warmer and drier conditions led to lower soil moisture throughout much of the East coast, which would reduce the evaporation of moisture into the air, thus lowering dewpoint temperatures. With less available moisture in the atmosphere, cloud cover was decreased, which lead to more sunlight, increased photochemistry, and higher levels of ozone across the state.

Additionally, the episode classification further verifies that the 2002 ozone season is a representative year for use in attainment demonstration modeling. The 2002 ozone season encompasses all five meteorological scenarios: eastern stacked highs, frontal approaches, Canadian highs, modified Canadian highs, progressive Canadian highs and the subcategory of tropical influence. Thus, the 2002 season provides an excellent case to evaluate various control strategies for maintaining the NAAQS for ozone.

For these reasons, the 2002 ozone season was selected for the episode to model for the attainment demonstration. Further details of the episode selection process, episode classification procedures, as well as the episodes classifications for the 2002 ozone season can be found in the Modeling Protocol (Appendix C).

2.4 Modeling Domains

2.4.1 Horizontal Modeling Domain

The CMAQ model was run in one-way nested grid mode. This allowed the larger outer domains to feed concentration data to the inner nested domain. One-way nesting is believed to be appropriate for the generally stagnant conditions experienced during Kentucky ozone episodes. Two-way nesting was not considered due to numerical and computational uncertainty associated with the technique.

The horizontal coarse grid modeling domain boundaries were determined through a national effort to develop a common grid projection and boundary. Since this national modeling domain was used in the VISTAS regional haze modeling, it was used for the attainment demonstration as well. A smaller 12-km grid, modeling domain was selected in an attempt to balance location of areas of interest, such as ozone and fine particulate matter nonattainment areas, as well as Class 1 and wilderness areas for regional haze. Processing time was also a factor in choosing a smaller 12-km grid, modeling domain.

The coarse 36-km horizontal grid domain covers the continental United States. This domain was used as the outer grid domain for MM5 modeling with the CMAQ domain nested within the MM5 domain. Figure 2.4.1-1 shows the MM5 horizontal domain as the outer most, blue grid with the CMAQ 36-km domain nested in the MM5 domain.

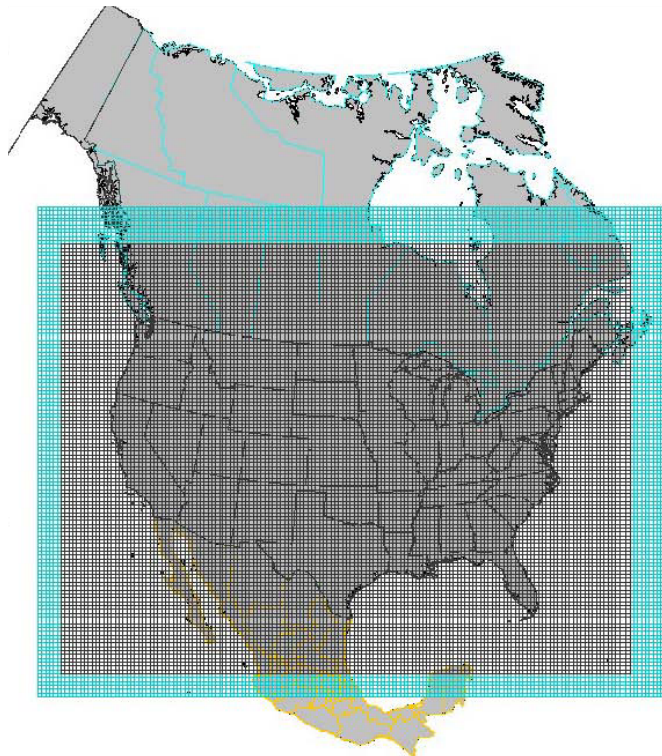


Figure 2.4.1-1: The MM5 horizontal domain is the outer most, blue grid, with the CMAQ 36-km domain nested in the MM5 domain.

To achieve finer spatial resolution in the VISTAS states, a one-way nested high resolution (12-km grid resolution) was used. Figure 2.4.1-2 shows the 12-km grid, modeling domain for the VISTAS region. This is the modeling domain on which the attainment test results are based. The KYDAQ did a study to determine if using a finer grid resolution provided different modeling results. Since the USEPA's attainment test uses the modeling results to determine the relative reductions in ozone between the base year and the future year, the KYDAQ determined that effectively the same attainment test results are obtained from 12-km grid modeling or 4-km grid modeling. Since 4-km grid modeling takes significantly more time and resources to run, the KYDAQ decided to use the VISTAS 12-km grid modeling results for this attainment demonstration.

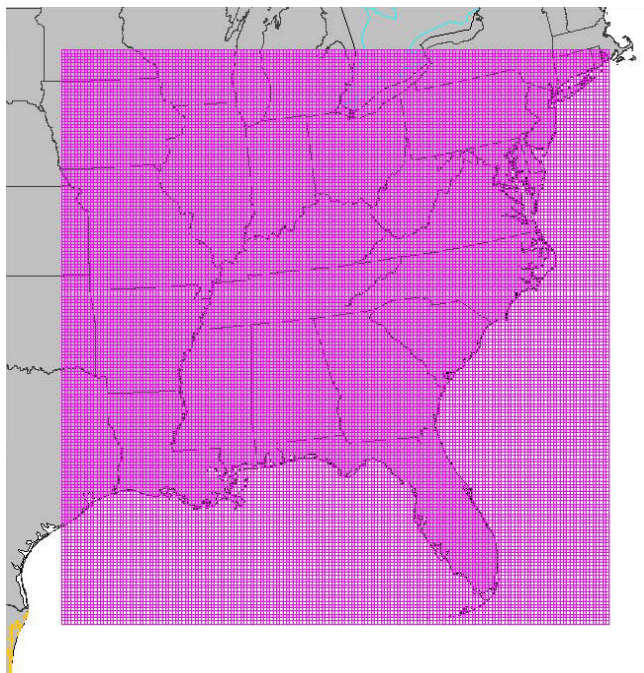


Figure 2.4.1-2: A more detailed view of the 12-km grid over the VISTAS region.

2.4.2 Vertical Modeling Domain

The CMAQ vertical structure is primarily defined by the vertical grid used in the MM5 modeling. The MM5 model employed a terrain following coordinate system defined by pressure, using 34 layers that extend from the surface to the 100 mb. Table 2.4.2-1 lists the layer definitions for both MM5 and for CMAQ. A layer-averaging scheme is adopted for CMAQ to reduce the computational cost of the CMAQ simulations. The effects of layer averaging were evaluated in conjunction with the VISTAS modeling effort and was found to have a relatively minor effect on the model performance metrics when both the 34 layer and a 19 layer CMAQ models were compared to ambient monitoring data.

Table 2.4.2-1: Vertical Layer Definition For MM5 and CMAQ

MM5 Simulation					CMAQ 19 Layers				
Layer	Sigma	Pressure (mb)	Height (m)	Depth (m)	Layer	Sigma	Pressure (mb)	Height (m)	Depth (m)
34	0.000	100	14662	1841	19	0.000	100	14662	6536
33	0.050	145	12822	1466		0.050	145		
32	0.100	190	11356	1228		0.100	190		
31	0.150	235	10127	1062		0.150	235		
30	0.200	280	9066	939		0.200	280		
29	0.250	325	8127	843	18	0.250	325	8127	2966
28	0.300	370	7284	767		0.300	370		
27	0.350	415	6517	704		0.350	415		
26	0.400	460	5812	652		0.400	460		
25	0.450	505	5160	607	17	0.450	505	5160	1712
24	0.500	550	4553	569		0.500	550		
23	0.550	595	3984	536		0.550	595		
22	0.600	640	3448	506	16	0.600	640	3448	986
21	0.650	685	2942	480		0.650	685		
20	0.700	730	2462	367	15	0.700	730	2462	633
19	0.740	766	2095	266		0.740	766		
18	0.770	793	1828	259	14	0.770	793	1828	428
17	0.800	820	1569	169		0.800	820		
16	0.820	838	1400	166	13	0.820	838	1400	329
15	0.840	856	1235	163		0.840	856		
14	0.860	874	1071	160	12	0.860	874	1071	160
13	0.880	892	911	158	11	0.880	892	911	158
12	0.900	910	753	78	10	0.900	910	753	155
11	0.910	919	675	77		0.910	919		
10	0.920	928	598	77	9	0.920	928	598	153
9	0.930	937	521	76		0.930	937		
8	0.940	946	445	76	8	0.940	946	445	76
7	0.950	955	369	75	7	0.950	955	369	75
6	0.960	964	294	74	6	0.960	964	294	74
5	0.970	973	220	74	5	0.970	973	220	74
4	0.980	982	146	37	4	0.980	982	146	37
3	0.985	986.5	109	37	3	0.985	986.5	109	37
2	0.990	991	73	36	2	0.990	991	73	36
1	0.995	995.5	36	36	1	0.995	995.5	36	36
0	1.000	1000	0	0	0	1.000	1000	0	0

2.5 Emission Inventory

There are five different emission inventory source classifications, stationary point and area sources, off-road and on-road mobile sources, and biogenic sources. Stationary point sources are those sources that emit greater than a specified tonnage per year and the data is provided at the facility level. Stationary area sources are those sources whose emissions are relatively small but

due to the large number of these sources, the collective emissions could be significant (i.e., dry cleaners, service stations, etc.). These types of emissions are estimated on the county level. Off-road mobile sources include equipment that can move, but do not use the roadways, i.e., lawn mowers, construction equipment, railroad locomotives, aircraft, etc. The emissions from these sources, like stationary area sources, are estimated on the county level. On-road mobile sources are automobiles, trucks, and motorcycles that use the roadway system. The emissions from these sources are estimated by vehicle type and road type and are summed to the county level. Biogenic sources are the natural sources like trees, crops, grasses and natural decay of plants. The emissions from these sources are estimated on a county level.

In addition to the various source classifications, there are also various types of emission inventories. The first is the actual base year inventory. This inventory is the base year emissions that correspond to the meteorological data, for this modeling effort is 2002. These emissions are used for evaluating the air quality model performance.

The second type of inventory is the typical base year inventory. This inventory is similar to the actual base year, however for sources that may have significant changes from year-to-year, a more typical emission value is used. In this modeling effort, typical emissions were developed for the electric generating units (EGUs) and the wildland fire emissions. The air quality modeling results using these emissions are used in calculating the relative response factors used in the attainment demonstration test.

The future year base inventory is an inventory developed for some future year for which attainment of the ozone standard is needed. For this modeling project, the future year inventory will be 2009. It is the future base year inventory that control strategies and sensitivities are applied to determine what controls beyond those measures already included in the future year base inventory, to which source classifications must be made in order to attain and maintain the ozone standard.

The attainment year inventory submitted by Kentucky will be 2008. As mentioned previously, Kentucky's mandatory attainment date is June 15th, 2009, well before the end of the 2009 ozone season. Thus the last complete year of data for attainment will be 2008. Due to limited changes between the 2008 and 2009 emission inventories as well as the adverse impact on resources, Kentucky believed it was appropriate, technically justified, legally correct, and wise use of available resources to rely on the 2009 VISTAS/ASIP modeling and weight of evidence analysis in lieu of conducting 2008 modeling for this area. U.S. EPA agreed in May of 2006 (See Appendix A).

In the sections that follow, a synopsis of the inventories used for each source classifications are discussed. The detail discussions of the emissions inventory development can be found in Appendix E and emission summaries by county for the Cincinnati-Hamilton, OH-KY-IN nonattainment area, are in Appendix D.

2.5.1 Stationary Point Sources

Point source emissions are emissions from individual sources that are in a fixed location. Generally, these sources must have permits in order to construct and/or operate and their emissions are inventoried on an annual basis. All sources emitting VOC are inventoried in Northern Kentucky on an annual basis. Large NO_x sources having minimum capacity to emit 100 tons per year (tpy) of a criteria pollutant, 10 tpy of a single hazardous air pollutant (HAP), or 25 tpy total of multiple HAPs are inventoried annually. Smaller sources have been inventoried less frequently. For the purposes of this modeling Point source emissions data can be grouped into EGU sources and other non-EGU sources.

Electric Generating Units

2002 continuous emissions monitoring (CEM) data reported to the USEPA's Acid Rain program or 2002 hourly emissions data provided by stakeholders, was used to determine the base year inventory for EGU sources. This data provides hourly emissions profiles that can be used to provide more accurate modeling of these large sources of NO_x. Since the NO_x emissions from EGU sources are a significant part of the emissions inventory, a typical base year emissions inventory was developed for these sources to avoid anomalies in emissions due to variability in meteorology, economic and outage factors in 2002. This approach is consistent with the USEPA's modeling guidance. To develop a typical year 2002 emissions inventory for EGU sources, for each unit the average CEM heat input for 2000 through 2004 was divided by the 2002 actual heat input to generate a unit specific normalizing factor. This normalizing factor was then multiplied by the 2002 actual emissions. The heat inputs for the period 2000 through 2004 were used since the modeling current design values use monitoring data from this same 5-year period. If a unit was shutdown for an entire year during the 2000 through 2004 period, the average of the years the unit was operational was used. If a unit was shutdown in 2002, but not permanently shutdown, the emissions and heat inputs for 2001 (or 2000) were used in the normalizing calculations.

As part of the VISTAS modeling, VISTAS and the Midwest Regional Planning Organization contracted with ICF Resources, L.L.C., to generate future year emission inventory for the electric generating sector of the contiguous United States using the Integrated Planning Model (IPM). IPM is a dynamic linear optimization model that can be used to examine air pollution control policies for various pollutants throughout the contiguous United States for the entire electric power system. The dynamic nature of IPM enables the projection of the behavior of the power system over a specified future period. The optimization logic determines the least-cost means of meeting electric generation and capacity requirements while complying with specified constraints including air pollution regulations, transmission bottlenecks, and plant-specific operational constraints. The versatility of IPM allows users to specify which constraints to exercise and populate IPM with their own datasets.

The IPM modeling runs took into consideration the USEPA's Clean Air Interstate Rule (CAIR) implementation.

Other Point Sources

For the non-EGU sources, the same inventory will be used for both the actual and typical base year emissions inventories. The non-EGU point category will use annual emissions as reported for the Consolidated Emissions Reporting Rule (CERR) for the year 2002. These emissions were temporally allocated to month, day, and hour using source category code (SCC) based allocation factors using the SMOKE emissions model.

The general approach for assembling future year data was to use recently updated growth and control data consistent with USEPA's CAIR analyses. This data was supplemented with state specific growth factors and stakeholder input on growth assumptions.

2.5.2 Stationary Area Sources

Stationary area sources include sources whose emissions are relatively small but due to the large number of these sources, the collective emissions could be significant (i.e., combustion of fuels for heating, structure fires, service stations, etc.). Emissions are estimated by multiplying an emission factor by some known indicator of collective activity, such as fuel usage, number of household or population. Stationary area source emissions are estimated on the county level.

The VISTAS/ASIP contractor calculated the area source inventory. Certain other area source controls will be discussed further in this document. The actual base year inventory will serve as the typical base year inventory for all area source categories except for wildland fires. For this source category, development of a typical year fire inventory provided the capability of using a comparable data set for both the base year and future years. Thus, fire emissions would remain the same for air quality modeling in both the base and any future years. The VISTAS Fire Special Interest Work Group was consulted and decided to use State level ratios of acres over a longer term record (three or more years) developed for each fire type relative to 2002. The 2002 acreage was then scaled up or down based on these ratios to develop a typical year inventory.

For categories other than wildland fires, the VISTAS/ASIP contractor generated the future base year emissions inventory used in the attainment demonstration modeling. Growth factors supplied from the states or the USEPA's CAIR emission projections were applied to project the controlled emissions to the appropriate year. In some cases, the USEPA's Economic Growth and Analysis System Version 5 growth factors were used if no growth factor was available from either the states or the CAIR growth factor files.

2.5.3 Off-Road Mobile Sources

Non-road mobile sources include sources that are mobile, but are not used on roadways, such as construction equipment, aircraft, railroad locomotives, lawn and garden equipment, etc. For the majority of the non-road mobile sources, the emissions were estimated using the USEPA's NONROAD2005c model. For the three source categories not included in the NONROAD model, i.e., aircraft engines, railroad locomotives and commercial marine, more traditional methods of estimating the emissions were used. The same inventory will be used for both the actual and typical base year emissions inventories for the non-road mobile sources.

For the source categories estimated using the USEPA's NONROAD model, the model was used to create a future base year inventory. The NONROAD model takes into consideration rules that are in effect that could impact the emissions from these source categories. For the commercial marine, railroad locomotives and airport emissions, the VISTAS/ASIP contractor calculated the future base year emissions using detailed inventory data (both before and after controls) for 1996 and 2010 obtained from the USEPA's Clean Air Interstate Rule Technical Support Document. When available, state specific growth factors were used.

2.5.4 Highway Mobile Sources

In order to accurately model the mobile source emissions in the Cincinnati-Hamilton, OH-KY-IN area, the newest version of the MOBILE model, MOBILE6.2, was used. Key inputs for the MOBILE model include information on the age and mix of the vehicles on the roads, the average speed on the roadways, any control technologies in place in an area to reduce emissions for motor vehicles (e.g., fuel programs), and weather conditions

The MOBILE model takes into consideration rules that are in effect that impact the emissions from this source sector. For highway mobile sources, the actual and typical year emissions were the same and the MOBILE model was run using input data reflective of 2002. The same model then is run for the future year emissions inventory using input data reflective of 2009. The 2002 and 2009 vehicle miles traveled (VMT), speeds, vehicle age and vehicle mix data was obtained from the Kentucky Transportation Cabinet (KYTC). For urban areas in Kentucky that run travel demand models (TDMs), VMT and speed data from TDMs were used. OKI, the regional planning agency for the Cincinnati-Hamilton, OH-KY-IN area is one of the areas that run a TDM, and the TDM domain covers the entire nonattainment area.

2.5.5 Biogenic Emission Sources

Biogenic emissions were prepared with the SMOKE-BEIS3 (Biogenic Emission Inventory System 3 version 0.9) preprocessor. SMOKE-BEIS3 is basically the Urban Airshed Model (UAM)-BEIS3 model, but also includes modifications to use MM5 data, gridded land use data, and science updates. The emission factors that are used in SMOKE-BEIS3 are the same as the emission factors in UAM-BEIS3.

The basis for the gridded land use data used by BEIS3 is the county land use data in the Biogenic Emissions Landcover Database version 3 (BELD3) provided by the USEPA. A separate land classification scheme, based upon satellite (AVHRR, 1 km spatial resolution) and census information, aided in defining the forest, agriculture and urban portions of each county.

3.0 Model Performance Evaluation

There are many aspects of model performance. This section will focus primarily on the methods and techniques recommended by the USEPA for evaluating the performance of the air quality model. Before the air quality model can be fully evaluated, an understanding of the meteorological modeling performance is needed to understand potential biases and errors that may be passed from the meteorological model directly into the air quality model. The meteorological modeling evaluation is fully documented in Appendix F and is briefly summarized in the next few paragraphs.

Generally speaking, the meteorological modeling performance was quite good at both the 36-km and 12-km grid resolutions. Synoptic features were routinely accurately predicted and the meteorological model showed considerable skill in replicating the state variables (e.g. temperature, mixing ratio, relative humidity, wind speed and direction, cloud cover, and precipitation). The meteorological modeling performance statistics fell within expected and acceptable ranges of error during the majority of the 2002 modeled year.

The meteorological modeling performance for Kentucky was very similar to the performance for the VISTAS/ASIP region for the 12-km modeling domain. Again, large-scale meteorological patterns were accurately predicted. The meteorological model demonstrated substantial skill throughout the entire year and was especially skillful during the summertime season from May through September.

Overall, excess wind speeds, increased relative humidity, more daytime cloud cover, and precipitation overestimations will likely contribute to slight under predictions of the daily maximum peak ozone concentration in the air quality model. The KYDAQ believes that the meteorological model performance is adequate for this modeling exercise and should produce credible inputs for the air quality modeling for the attainment demonstration for the Cincinnati-Hamilton OH-KY-IN area.

With the meteorological modeling performance summarized, the first step in the air quality modeling process is to verify the model's performance in terms of its ability to predict the ozone in the right locations and at the right levels. To do this, the actual base year model predictions are compared to the ambient data observed in the historical season. This verification is a combination of statistical and graphical evaluations. If the model appears to be producing ozone in the right locations for the right reasons, then the model can be used as a predictive tool to evaluate various control strategies and their effects on ozone. The purpose of the model performance evaluation is to assess how accurately the model predicts ozone levels observed in the historical season. The key statistical measures that were used to evaluate model performance are as follows:

1. Comparison of modeled mean of ozone to the observed mean of ozone. This metric is an evaluation of how, on average across the modeling period, the model compares to the observed values.
2. Bias in the model is calculated by taking the difference between the modeled mean and the observed mean.

3. Normalized bias is calculated by taking the bias for each observation/prediction pair, and then dividing by the number of pairs that are used in the calculations. The USEPA recommends that normalized bias fall between $\pm 5 - 15$ percent.
4. Gross error. For the entire modeling domain, gross error for all pairs above 60 parts per billion (ppb) of ozone was calculated. For the northern Kentucky 8-hour ozone nonattainment area, the gross error was calculated on the daily 8-hour ozone maximums. The USEPA guidance suggests that gross error can be interpreted as precision of the model. This metric is typically used to compare various modeling applications. The USEPA recommends that the gross error of all pairs >60 ppb be less than 30-35 percent.

These statistics will be presented in the sections that follow for the entire 12-km modeling domain and for the northern Kentucky 8-hour ozone nonattainment area.

Another method of evaluating model performance is reviewing spatial plots and time series plots of the modeled versus observed data. These graphical plots aid in getting a better understanding of how the model is performing over the whole domain.

Only the model performance evaluation for the 12-km grid domain will be discussed in the subsections to follow. For the full model performance evaluation for both the 36-km and 12-km grid domains, please refer to Appendix G.

3.1 Domain-Wide Performance

The 8-hour ozone statistical data was calculated for the 12-km domain for the ASIP states, Kentucky, Ohio, and Indiana and is presented in Tables 3.1-1. The mean normalized bias was well within the recommended $\pm 5-15$ percent for the entire season (May through September). When looking at the individual monthly statistics for August and September in Kentucky, Ohio, and Indiana, the mean normalized bias was slightly outside the suggested range. This suggests an under prediction of ozone toward the end of the summer, however the KYDAQ does not believe this slight under prediction for August and September impacts the overall modeling results. The mean normalized gross error was significantly below the 30-35 percent range at the 60 ppb threshold for all regions. These statistical metrics were used as a first screening of the model performance.

Table 3.1-1. 12-km Domain Model Statistics for 8-Hour Ozone

Region/Month	Modeled Mean (ppb)	Observed Mean (ppb)	Mean Bias (ppb)	Mean Normalized Bias (%)	Mean Normalized Gross Error (%)
ASIP States combined					
May	61.26	67.69	-6.44	-8.96	12.47
June	62.62	70.99	-8.37	-11.37	14.02
July	62.73	70.85	-8.12	-10.90	14.74
August	61.33	72.57	-11.24	-14.92	16.98
September	60.81	71.98	-11.17	-14.98	17.07
Mean (May-September)	61.75	70.82	-9.07	-12.23	15.06
Kentucky					
May	60.71	66.61	-5.90	-8.57	10.05
June	63.79	69.84	-6.05	-8.21	11.80
July	66.30	70.23	-3.93	-5.20	11.87
August	62.93	70.79	-7.86	-10.55	14.19
September	65.40	73.22	-7.83	-10.69	13.99
Mean (May-September)	63.83	70.14	-6.31	-8.64	12.38
Ohio					
May	62.31	65.83	-3.52	-5.22	8.69
June	64.66	74.43	-9.77	-12.57	15.29
July	63.33	73.15	-9.82	-12.67	15.92
August	62.54	73.18	-10.63	-13.97	16.54
September	65.66	74.49	-8.83	-11.40	14.73
Mean (May-September)	63.70	72.22	-8.51	-11.17	14.23

3.1.1 Spatial Plots

Appendix G has all of the domain-wide spatial plots of modeled 1-hour and 8-hour maximum ozone with the observations overlaid for the days used in the relative response factor calculations. In this section, only representative days will be displayed (Figures 3.1.1-1 and 3.1.1-8). Overall the model does well with the spatial extent of the higher ozone concentrations. There is a slight under prediction of the ozone in the model, most notably in the 1-hour ozone plots. Higher ozone concentrations are seen in the urban areas, where it would be expected. In general, the KYDAQ believes the model does an acceptable job capturing the spatial distribution and concentration of ozone in the northern Kentucky region.

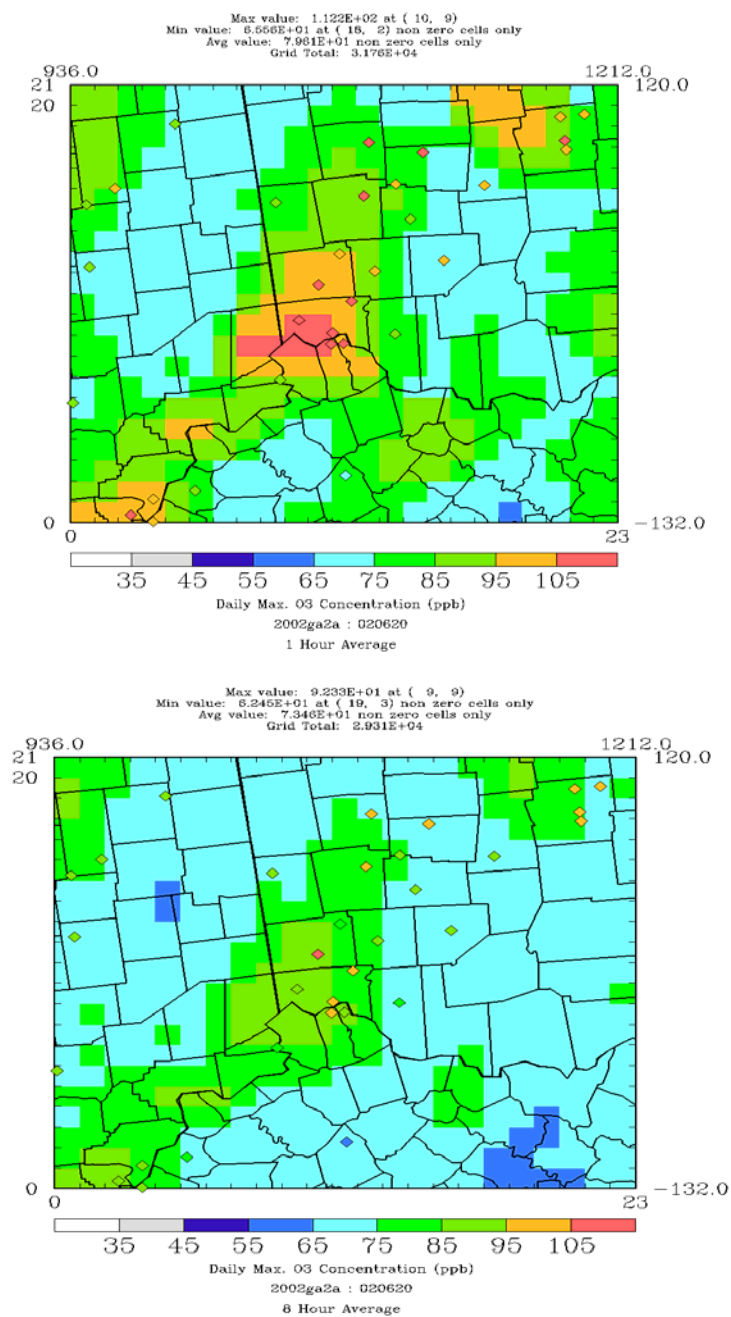


Figure 3.1.1-1 Spatial plots for modeled predicted and observed peak 1-hour (top) and 8-hour (bottom) ozone concentrations for June 20, 2002.

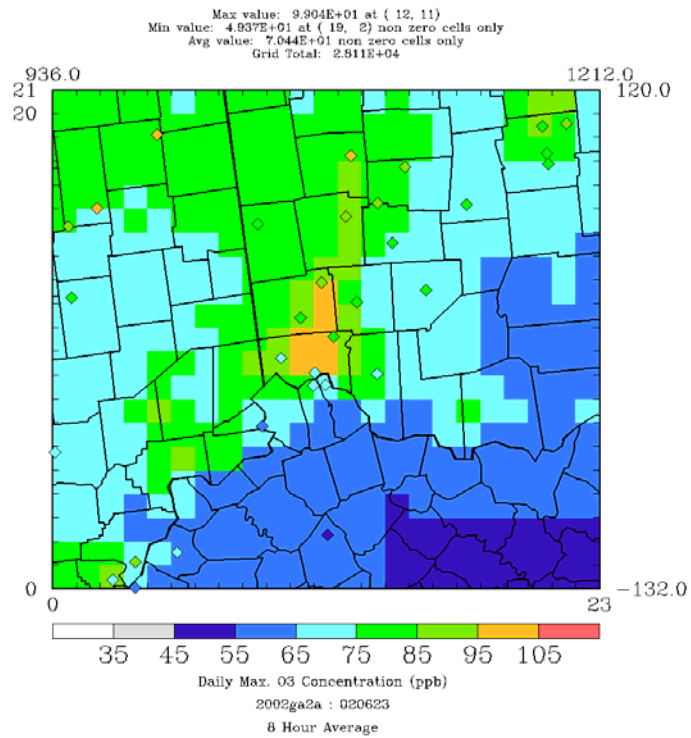
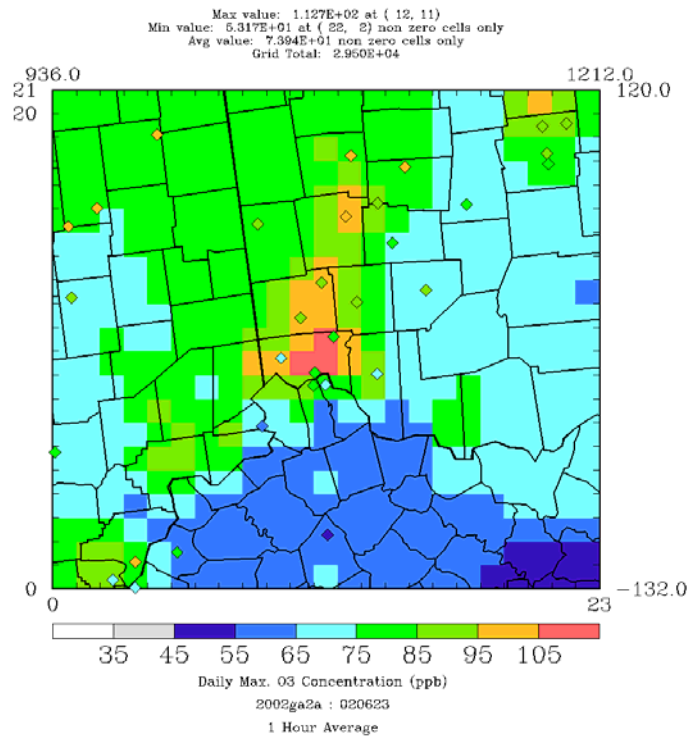


Figure 3.1.1-2 Spatial plots for modeled predicted and observed peak 1-hour (top) and 8-hour (bottom) ozone concentrations for June 23, 2002.

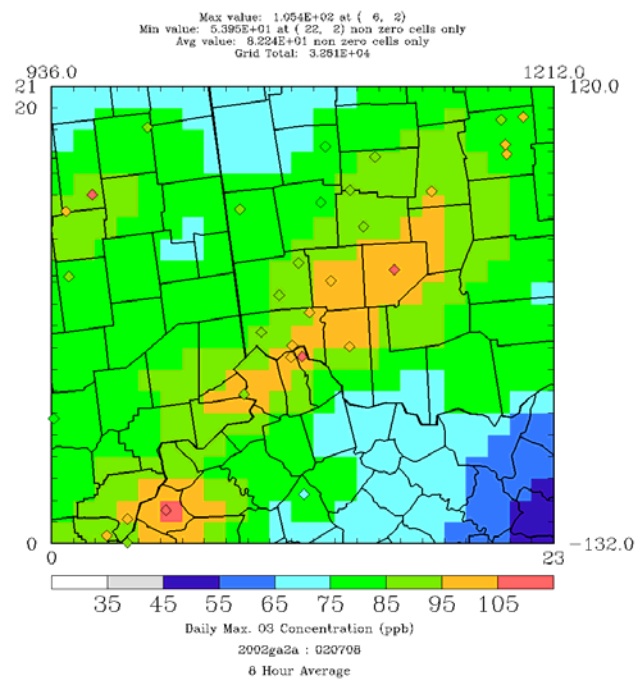
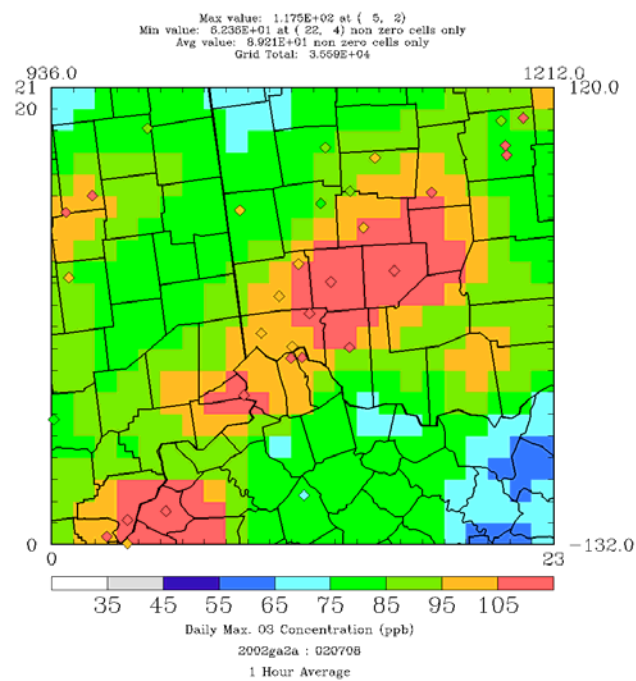


Figure 3.1.1-3 Spatial plots for modeled predicted and observed peak 1-hour (top) and 8-hour (bottom) ozone concentrations for July 8, 2002.

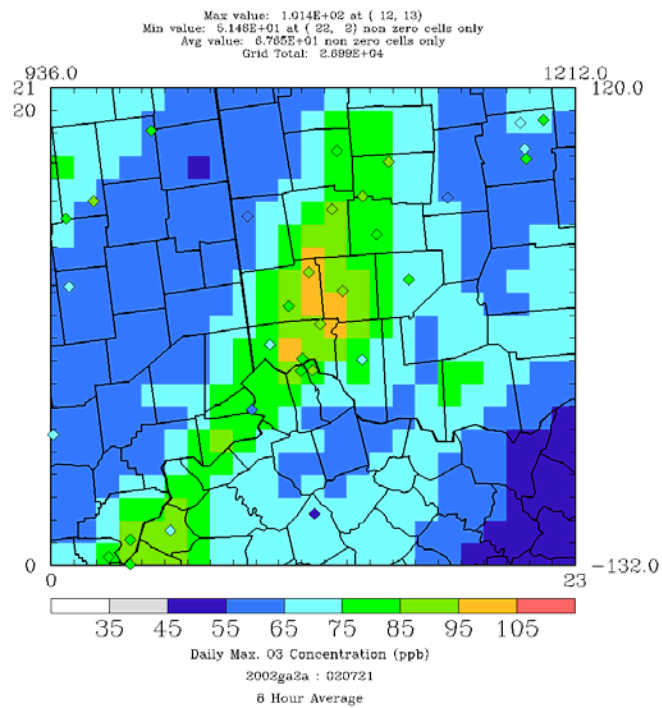
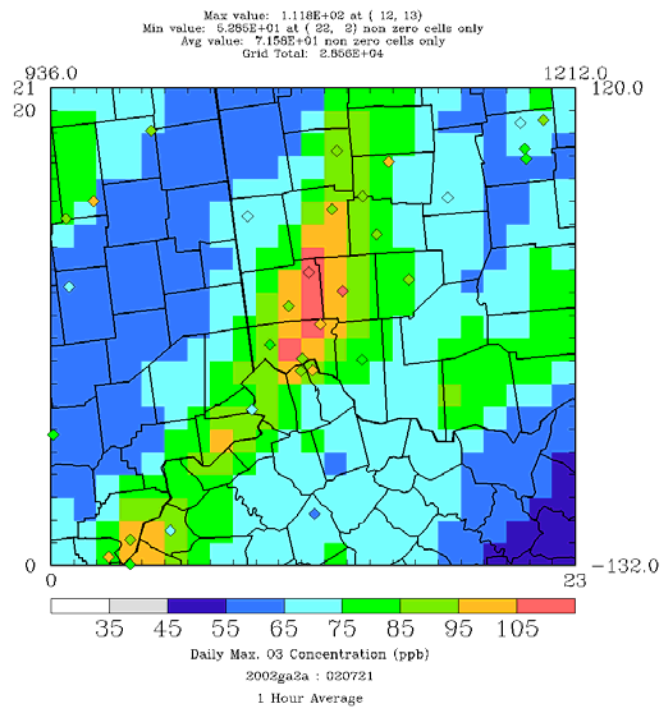


Figure 3.1.1-4 Spatial plots for modeled predicted and observed peak 1-hour (top) and 8-hour (bottom) ozone concentrations for July 21, 2002.

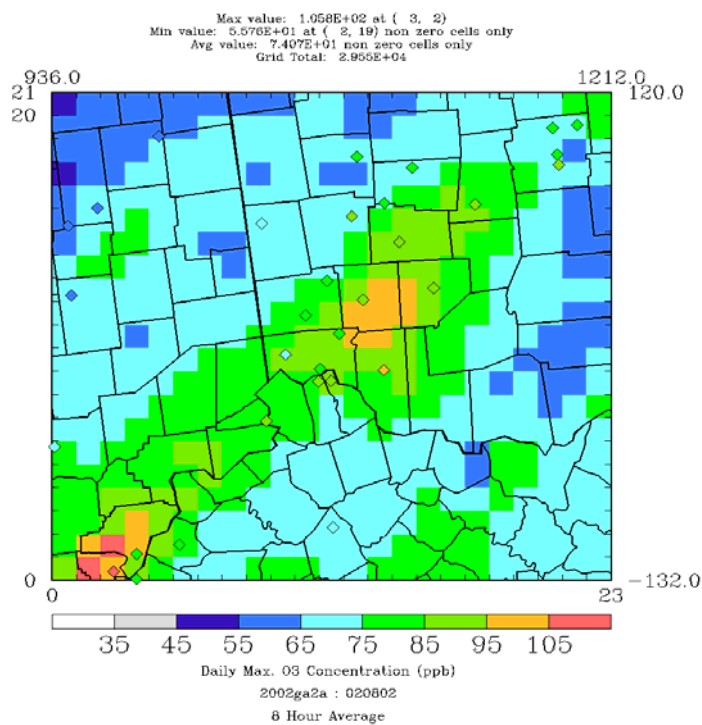
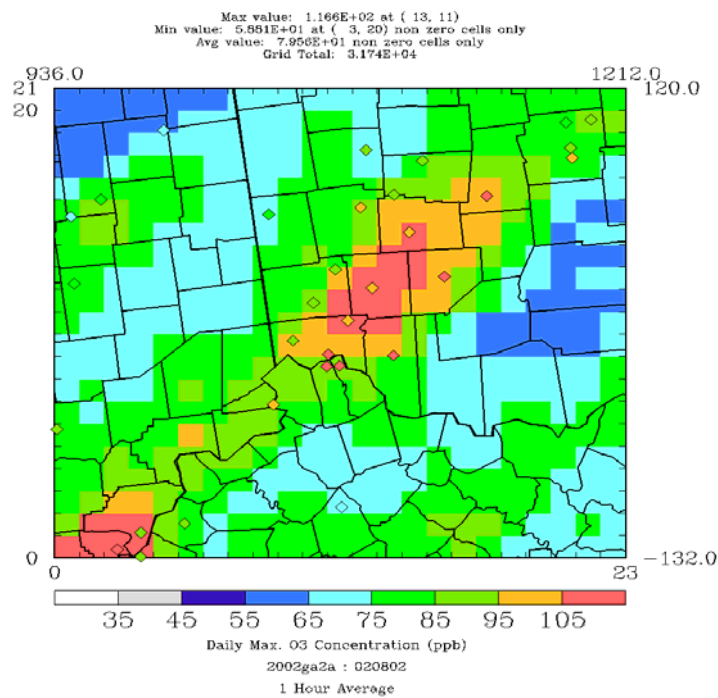


Figure 3.1.1-5 Spatial plots for modeled predicted and observed peak 1-hour (top) and 8-hour (bottom) ozone concentrations for August 2, 2002.

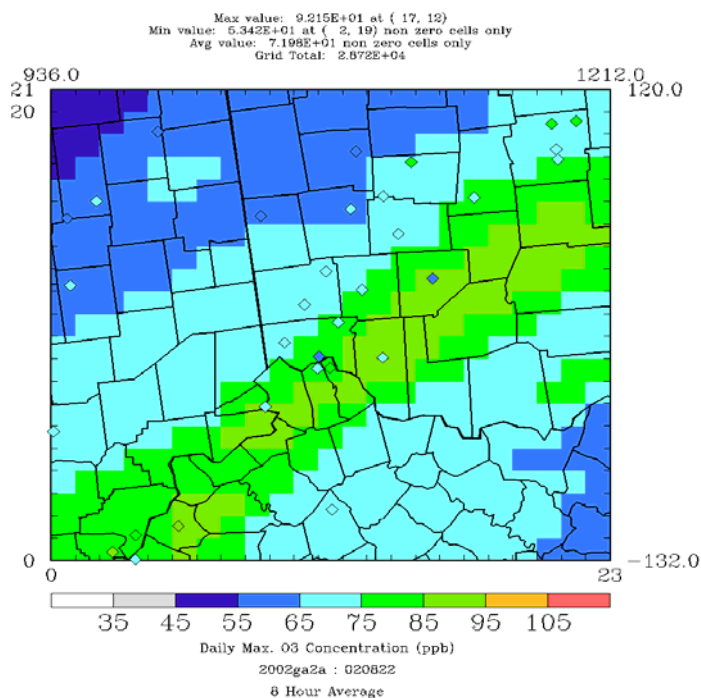
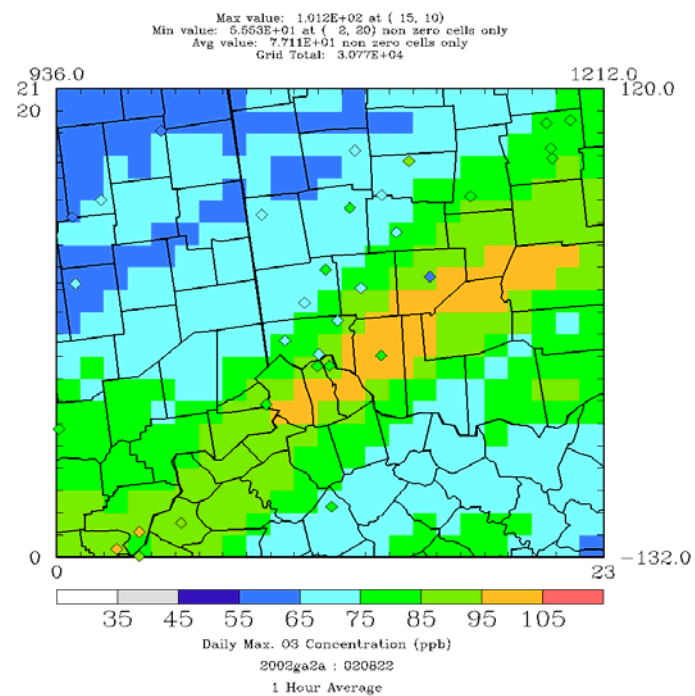


Figure 3.1.1-6 Spatial plots for modeled predicted and observed peak 1-hour (top) and 8-hour (bottom) ozone concentrations for August 22, 2002.

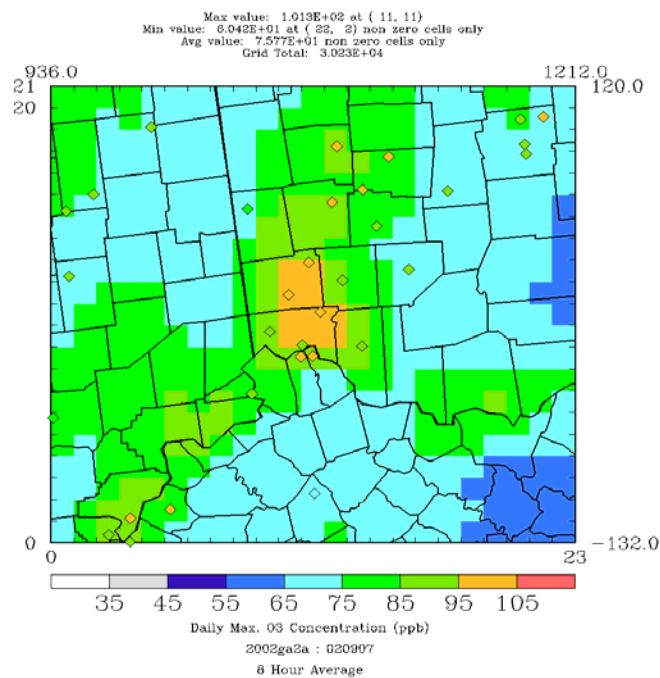
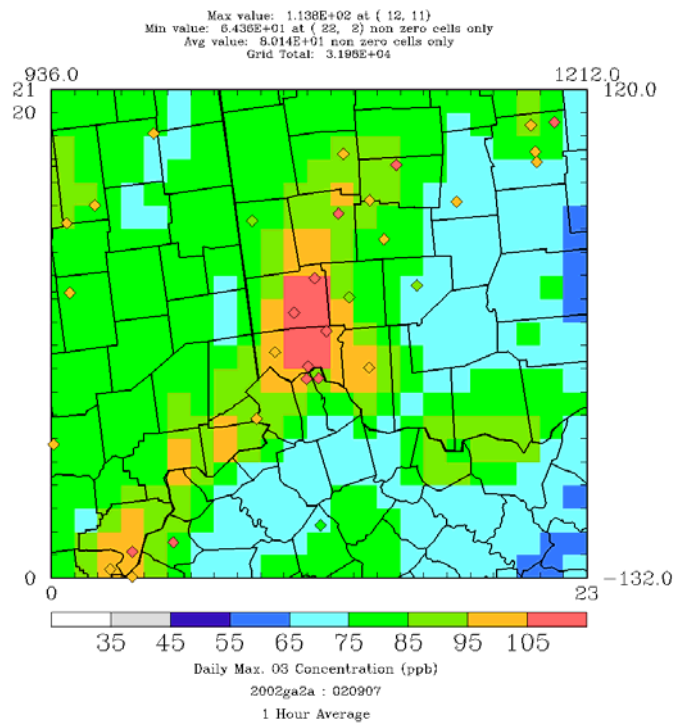


Figure 3.1.1-7 Spatial plots for modeled predicted and observed peak 1-hour (top) and 8-hour (bottom) ozone concentrations for September 7, 2002.

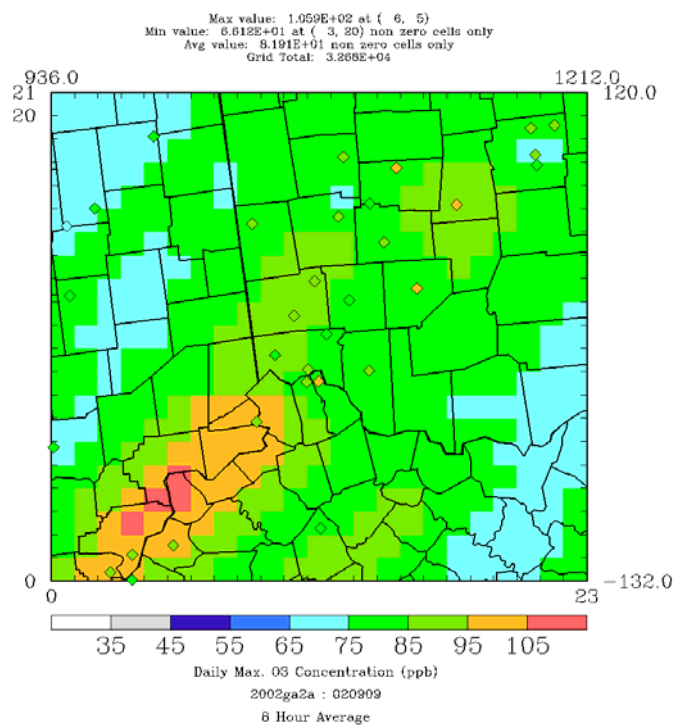
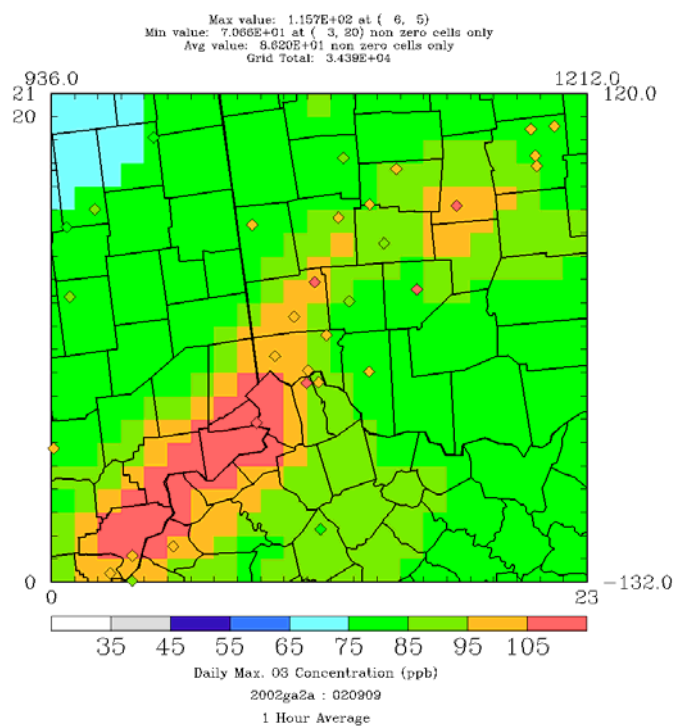


Figure 3.1.1-8 Spatial plots for modeled predicted and observed peak 1-hour (top) and 8-hour (bottom) ozone concentrations for September 9, 2002.

3.1.2 Scatter Plots

The KYDAQ is most concerned about how the model performed for Kentucky, Ohio, and Indiana and secondarily for the whole 12-km domain. For this reason, the scatter plots below are for the two states and the domain-wide scatter plots can be found in Appendix G. The model performance scatter plots of modeled predicted versus observed for 1-hour and 8-hour ozone has been compiled for each month used in the attainment test (May through September). Only the 8-hour ozone scatter plots for the three months (June through August) in which the majority of the modeled days used in the relative response factor are shown. Although there are some outliers, the overall performance is good for the 2002 ozone season. The majority of the points fall within the acceptable limits of good model performance.

Kentucky scatter plots

Figure 3.1.2-1 through 3.1.2-3 displays the scatter plots for 8-hour ozone for June, July and August for all of the monitoring sites in Kentucky. The 1-hour ozone scatter plots and the remaining 8-hour ozone scatter plots can be found in Appendix G. Overall, for the Kentucky monitoring sites the model performance is good. Although there are some days where over predictions and under predictions are observed, in general most days fall within acceptable ranges of the 1:1 line.

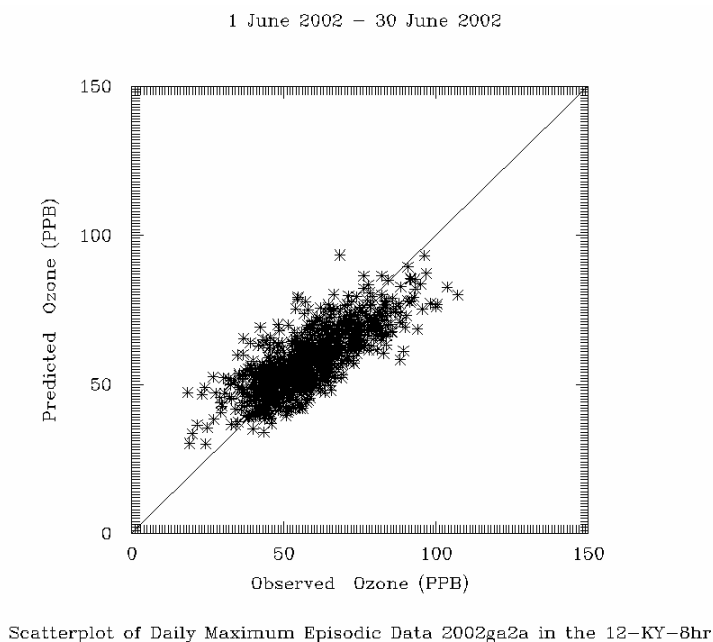
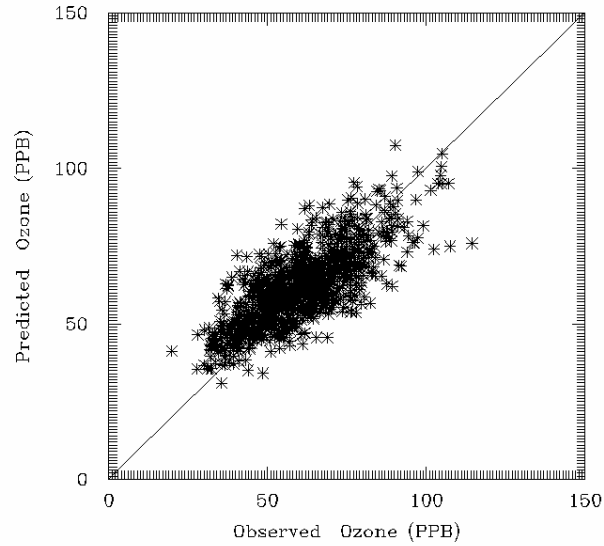


Figure 3.1.2-1 8-hour ozone scatter plot for Kentucky 12-km grid for June 2002

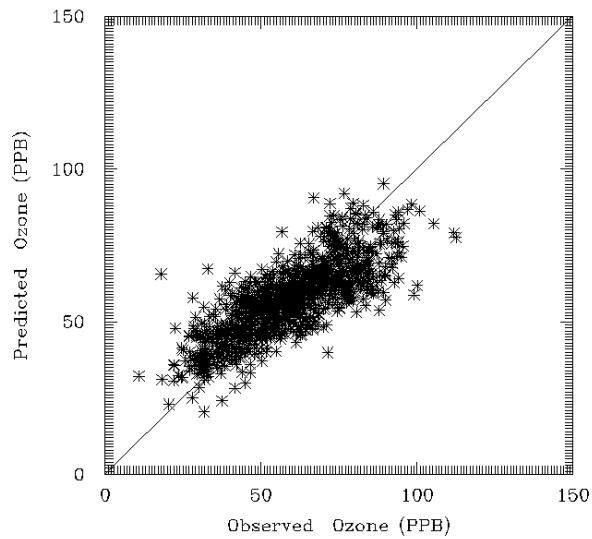
1 July 2002 – 31 July 2002



Scatterplot of Daily Maximum Episodic Data 2002ga2a in the 12-KY-8hr

Figure 3.1.2-2 8-hour ozone scatter plots for Kentucky 12-km grid for July 2002

1 Aug. 2002 – 31 Aug. 2002



Scatterplot of Daily Maximum Episodic Data 2002ga2a in the 12-KY-8hr

Figure 3.1.2-3 8-hour ozone scatter plots for Kentucky 12-km grid for August 2002

Ohio scatter plots

Figure 3.1.2-4 through 3.1.2-6 displays the scatter plots for 8-hour ozone for June, July and August for all of the monitoring sites in Ohio. The 1-hour ozone scatter plots and the remaining 8-hour ozone scatter plots can be found in Appendix G. Overall, the model performance is good for the Ohio monitoring sites. Again, although there are some days where over predictions and under predictions are observed, in general most days fall within acceptable ranges of the 1:1 line.

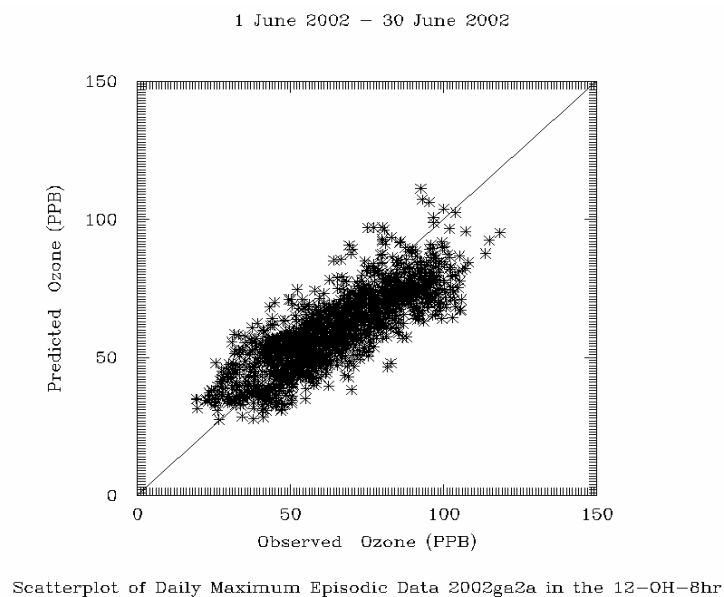


Figure 3.1.2-4 8-hour ozone scatter plots for Ohio 12-km grid for June 2002

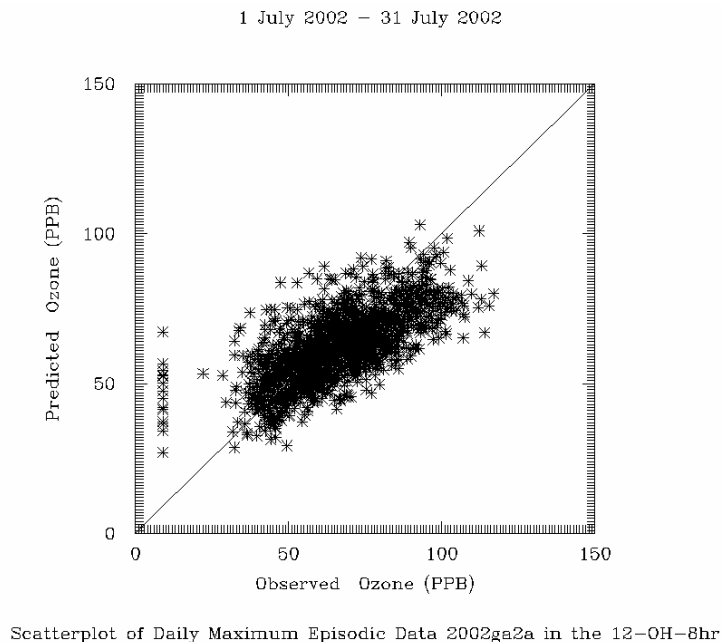


Figure 3.1.2-5 8-hour ozone scatter plots for Ohio 12-km grid for July 2002

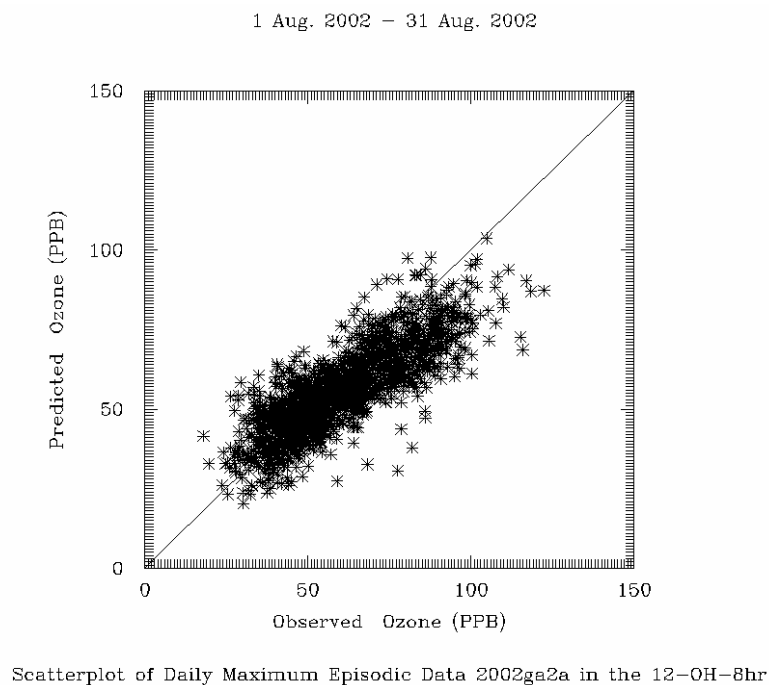
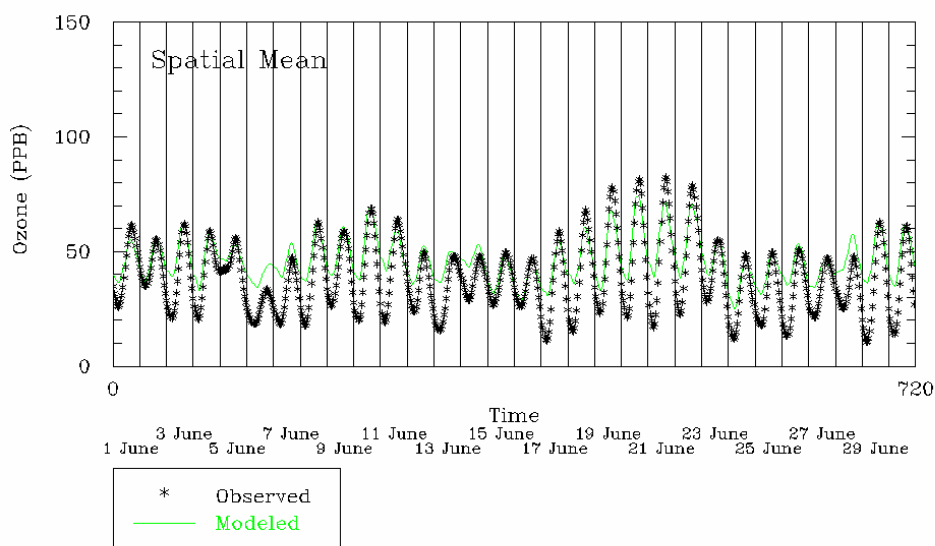


Figure 3.1.2-6 8-hour ozone scatter plots for Ohio 12-km grid for August 2002

3.1.3 Time Series Plots

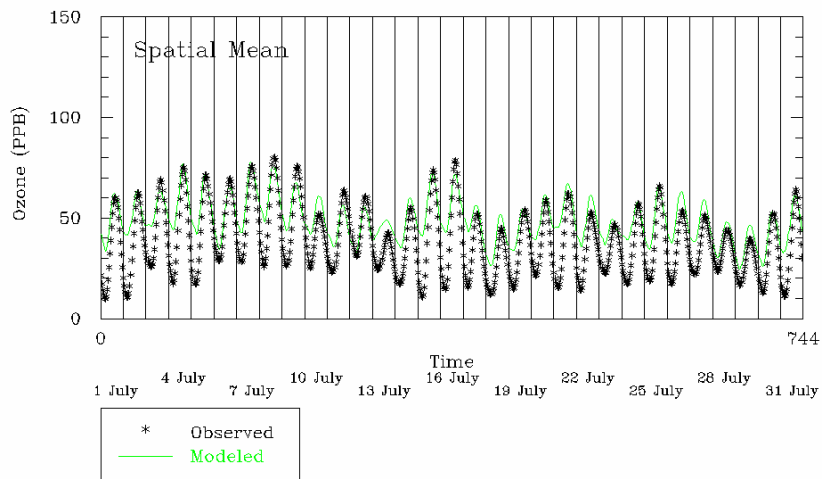
Following are 8-hour time series plots from the 12 km domain for the Kentucky monitors for June through August. The time series presents the observed values (black *'s) and the predicted values (green lines) by month. The 1-hour and 8-hour ozone time series plots for the ASIP region, Kentucky and Ohio can be found in Appendix G.

The model predicts the overall diurnal pattern well, however it tends to under predict peak values and over predict minimum values. In particular the last few days of August shows the model not handling the prediction of the absolute value of ozone well. Overall, the model is within acceptable tolerances for model performance.



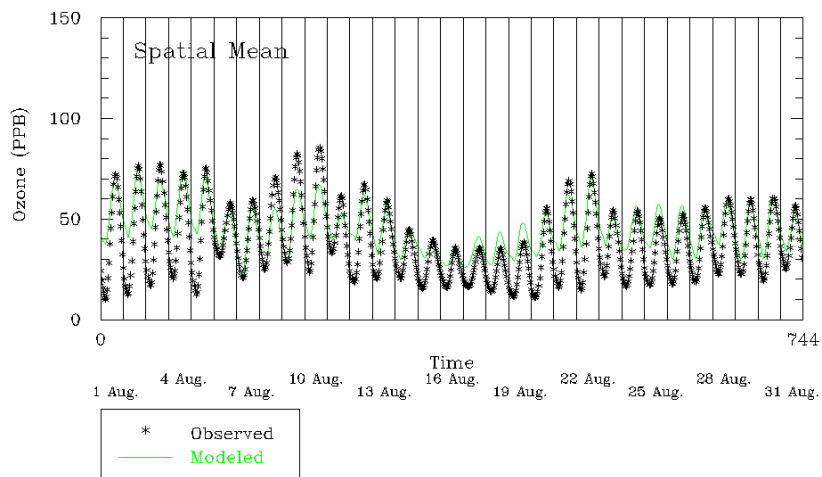
Neighborhood Spatial Mean 2002ga2a in the 12-KY-8hr

Figure 3.1.3-1 Time series plot of model predicted versus mean 8-hour observed for Kentucky monitors for June 2002.



Neighborhood Spatial Mean 2002ga2a in the 12-KY-8hr

Figure 3.1.3-2 Time series plot of model predicted versus mean 8-hour observed for Kentucky monitors for July 2002.



Neighborhood Spatial Mean 2002ga2a in the 12-KY-8hr

Figure 3.1.3-3 Times series plot of model predicted versus mean 8-hour observed for Kentucky monitors for August 2002

3.1.4 Domain-Wide Summary

Overall, the model performance for Kentucky and Ohio throughout the ozone season is good. For the most part, mean normalized bias and mean normalized gross error are within the recommended limits for good model performance. The model seems to do a good job capturing ozone concentrations through various episode-clean out cycles. There are some instances of under and over predictions, but for the majority of the time the model does well simulating the afternoon ozone peak throughout Kentucky and Ohio. The scatter plots show that the model did well. The KYDAQ believes that the model performance is well within the limits of acceptable performance established in the USEPA's Guidance On The Use Of Models And Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze (*"Attainment Guidance"*).

3.2 The Northern Kentucky Nonattainment Area Model Performance Evaluation

Below is the model performance evaluation for the Northern Kentucky nonattainment area. Included are visual (e.g. time series) and statistical measures. These evaluation products include:

1. Time series plots showing how the model's predicted ozone compares to the observed ozone at the monitor within the same grid cell. This is considered the most stringent of the model performance evaluation procedures since it requires the evaluation of the model's ability to predict the observed ozone in the location where it was observed over all hours of the episode.
2. Statistical measures for entire nonattainment area and by monitor in the region. Statistical measures include mean bias, mean normalized bias, and mean normalized gross error. Like the time series, the statistics compare the observed ozone at the monitor to the grid cell where the monitor is located.

3.2.1 Time Series Plots

The following are the June through August time series plots for the 12km grid domain for the monitors located in Boone, Campbell, and Kenton Counties, respectively. The time series presents the observed values (green line) and the predicted values (red line). Presented here are just the 8-hour ozone plots for these monitors, all of the May through September, 1-hour and 8-hour ozone time series plots for the monitors in the nonattainment area can be found in Appendix G.

As with the larger domain time series plots, the air quality model tends to slightly under predict peak 8-hour ozone values. The over prediction of the nighttime minimum issue is more noticeable in the individual monitoring site time series, especially these more urbanized sites due to the higher night time nitrogen oxide (NOx) environment found in such a urban area. The NOx emissions titrate the ozone after sunset and the ozone levels decrease dramatically. The air quality model does not replicate this type of phenomenon very well. The nighttime minimum over prediction is not an issue with respect to the modeled attainment test and is therefore not of

significant concern in this modeling exercise. The ability of the air quality model to accurately capture the synoptic cycles from high ozone episodes to very clean periods is best demonstrated in these individual monitor time series. Despite the under prediction of some of the 8-hour ozone daily maximum and the over night over predictions, the KYDAQ concludes that the air quality modeling continues to meet all requirements for further application in the modeled attainment test.

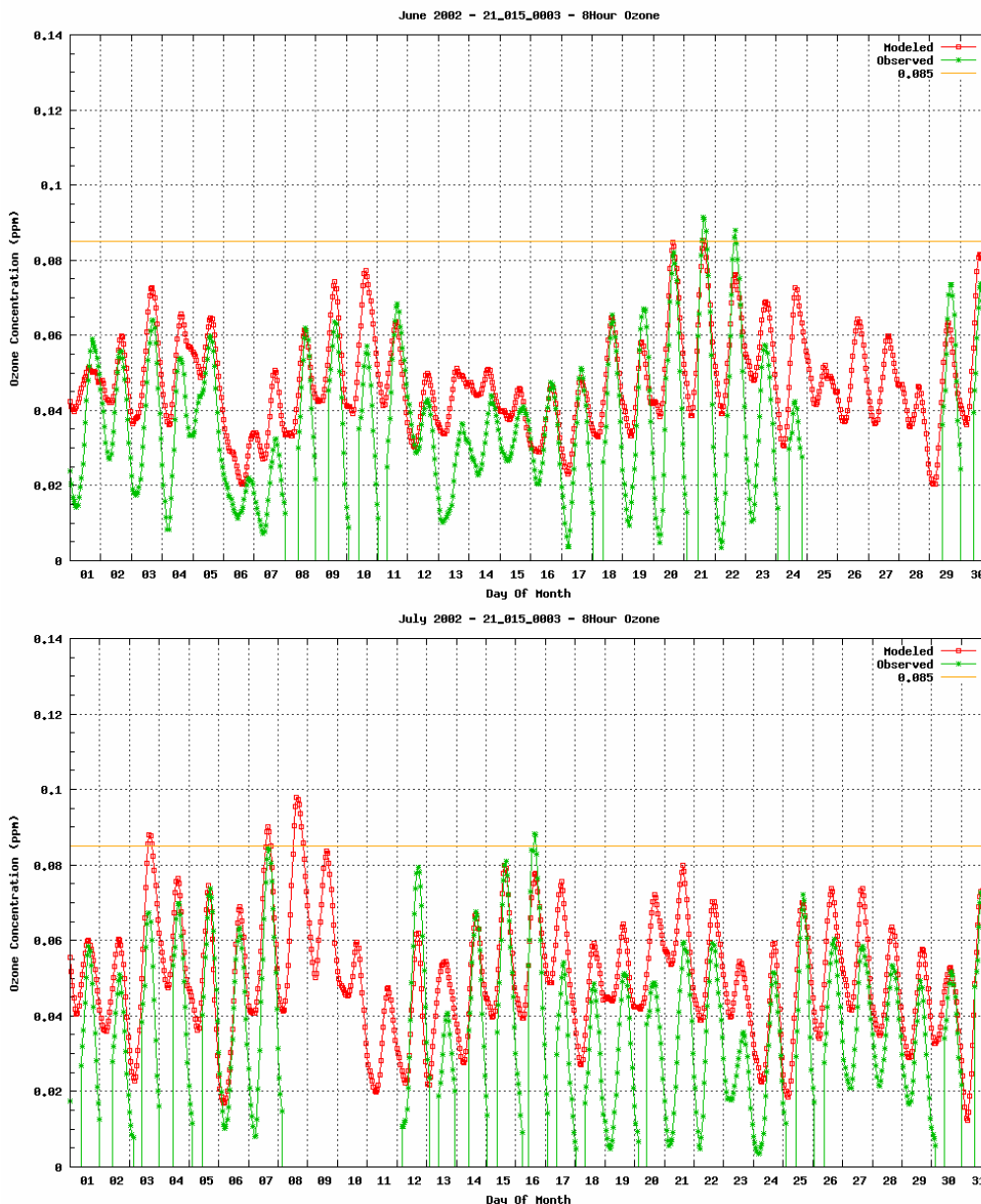


Figure 3.2.1-1 Time series plots of model predicted versus 8-hour ozone concentrations for the Boone County monitor for June (top) and July (bottom).

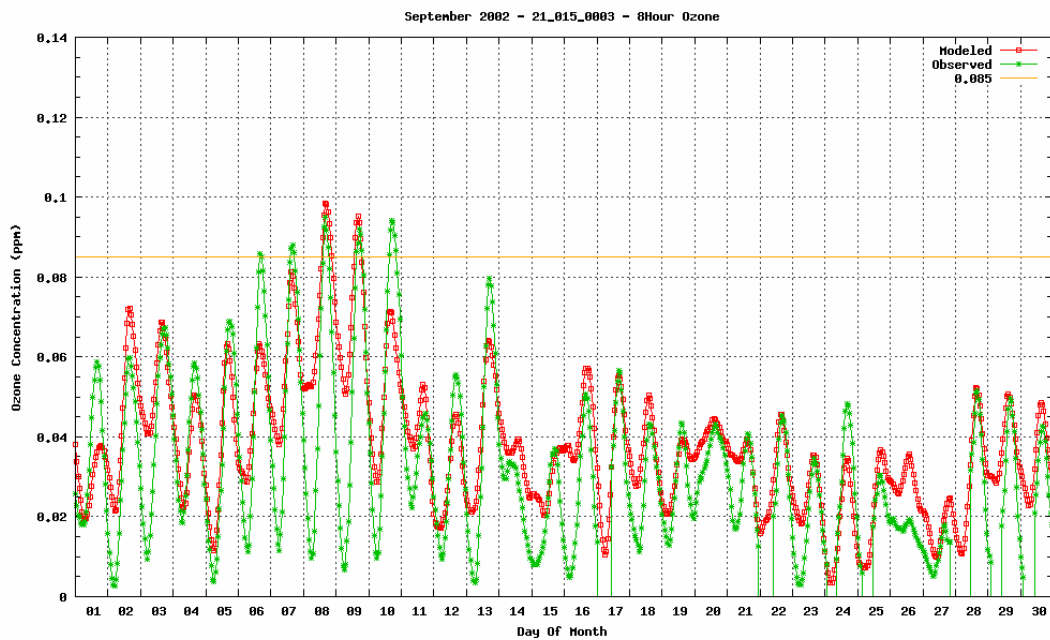
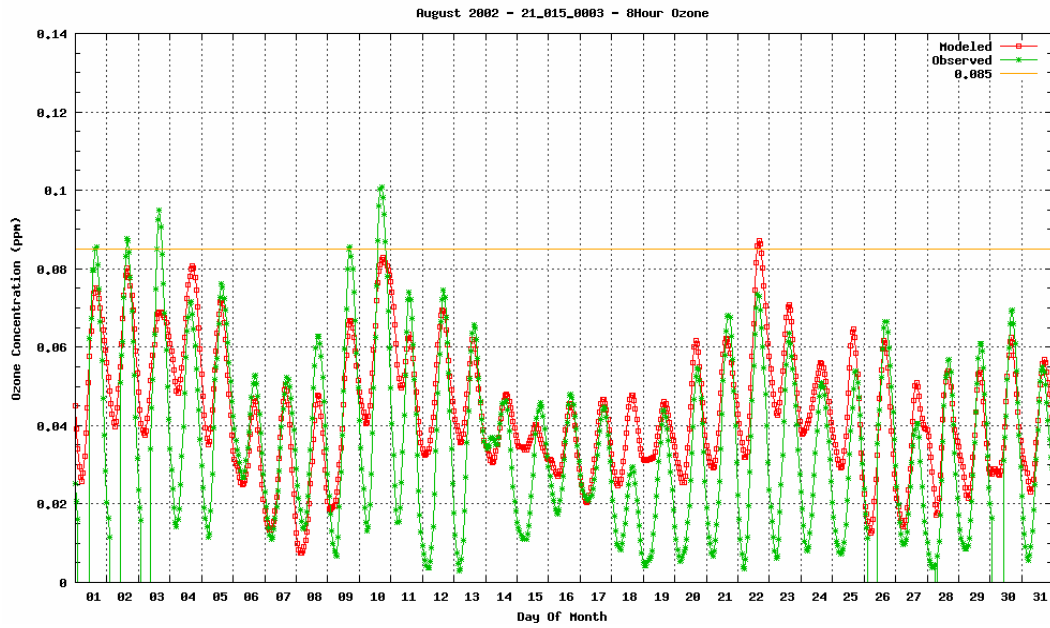


Figure 3.2.1-2 Time series plots of model predicted versus 8-hour ozone concentrations for the Boone County monitor for August (top) and September (bottom).

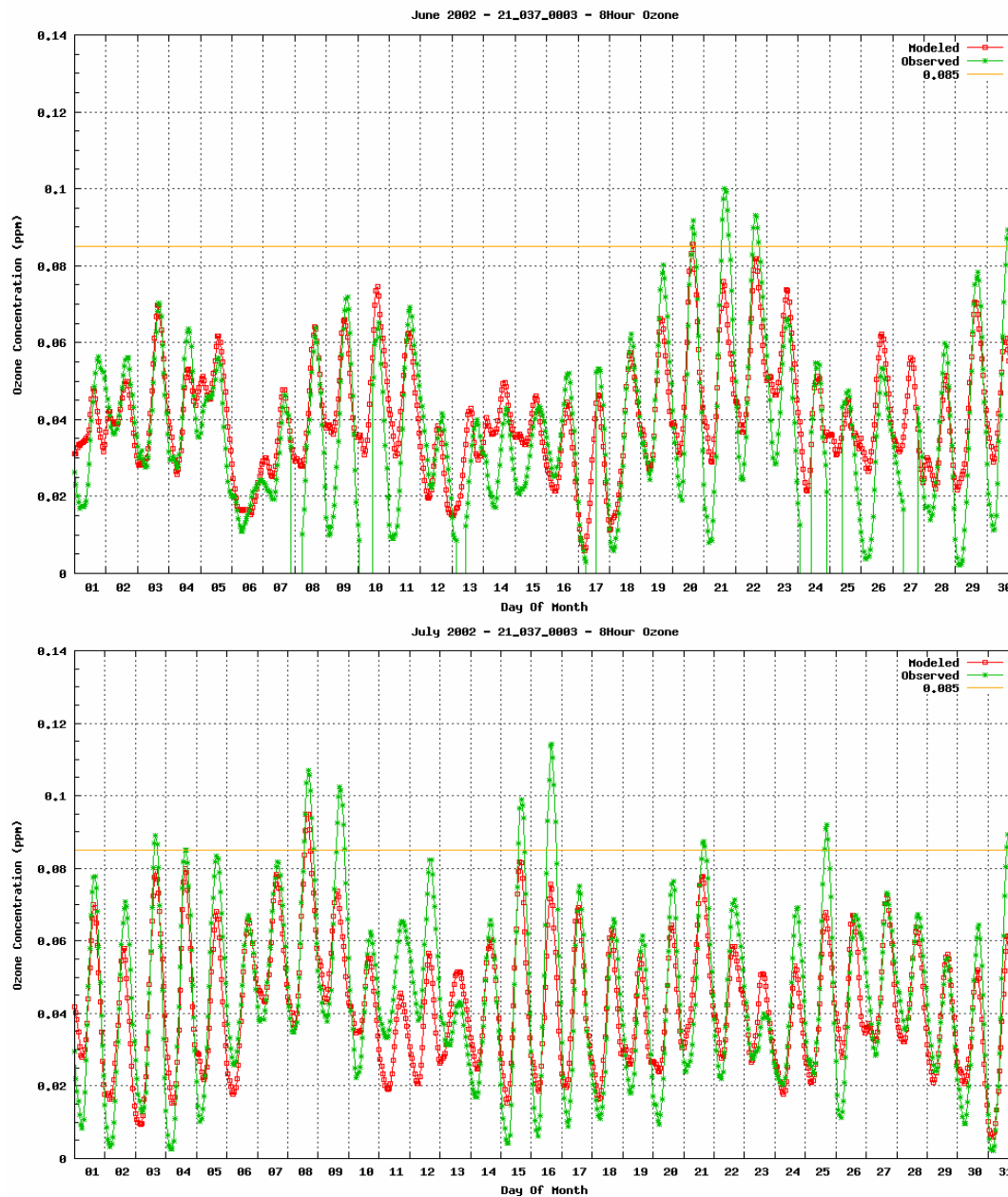


Figure 3.2.1-3 Time series plots of model predicted versus 8-hour ozone concentrations for the Campbell County monitor for June (top) and July (bottom).

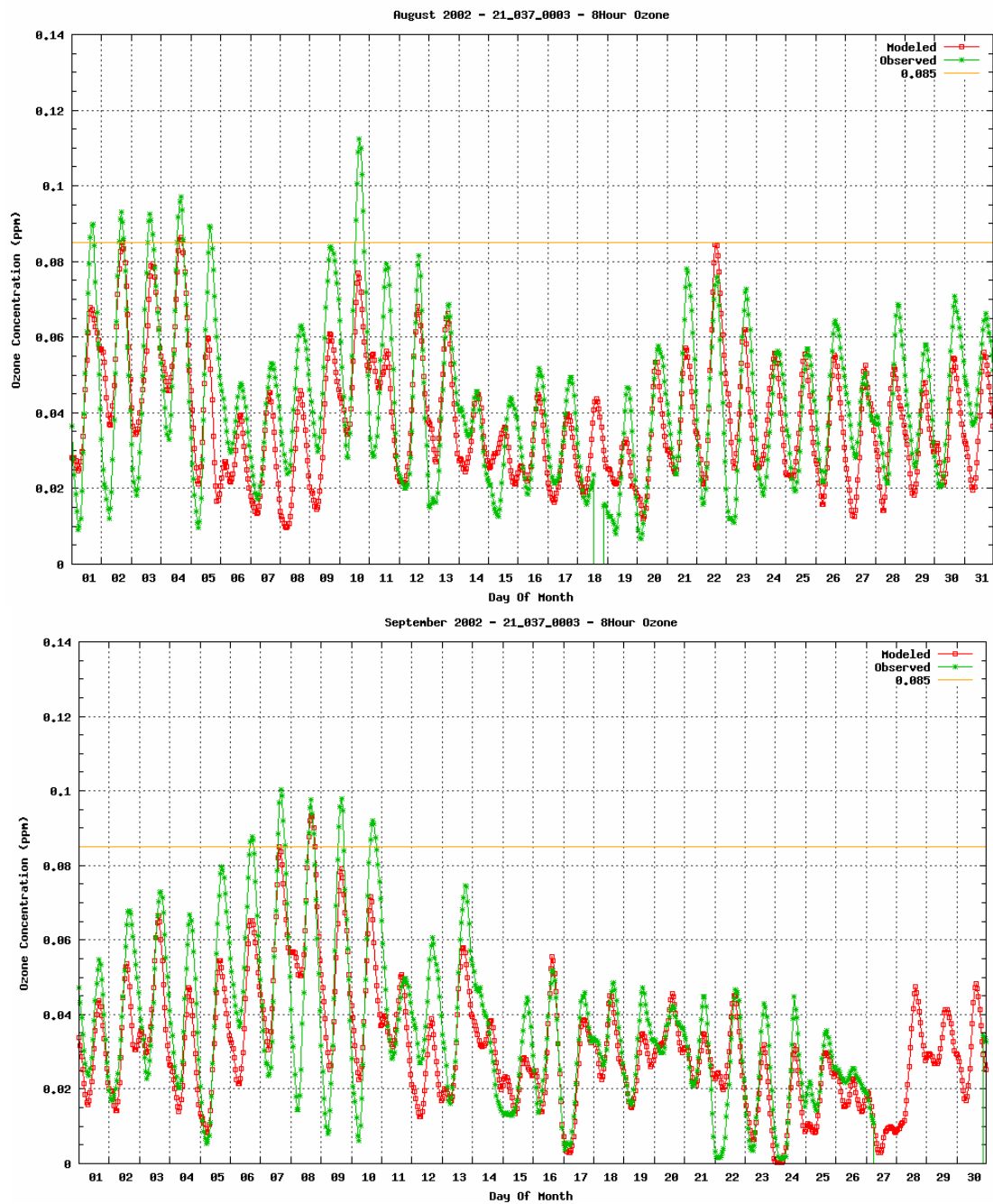


Figure 3.2.1-4 Time series plots of model predicted versus 8-hour ozone concentrations for the Campbell County monitor for August (top) and September (bottom).

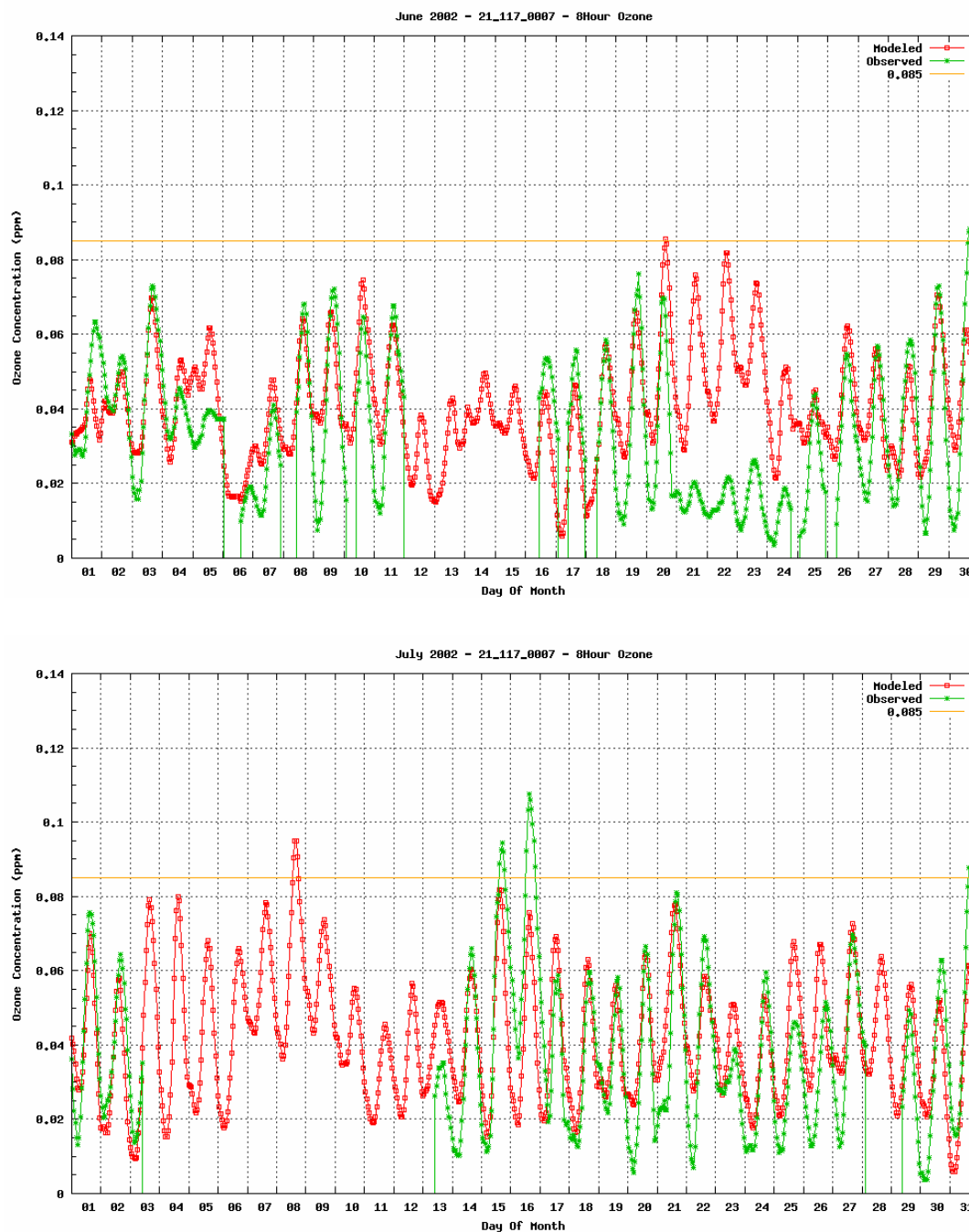


Figure 3.2.1-5 Time series plots of model predicted versus 8-hour ozone concentrations for the Kenton County monitor for June (top) and July (bottom).

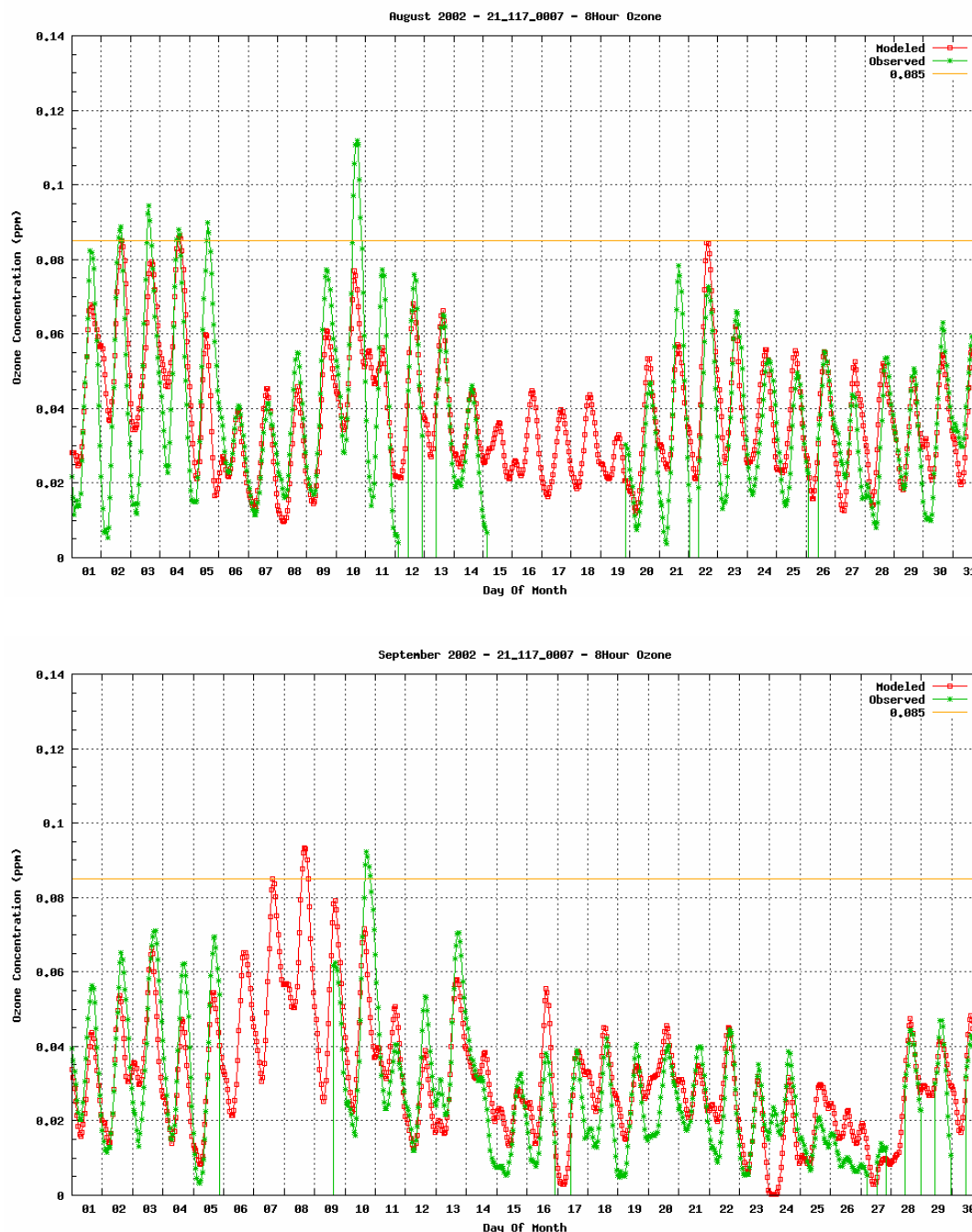


Figure 3.2.1-6 Time series plots of model predicted versus 8-hour ozone concentrations for the Kenton County monitor for August (top) and September (bottom).

3.2.2 Area and Monitor Statistics

Table 3.2.2-1 displays the model performance statistics comparing the modeled 8-hour ozone mean and the observed 8-hour ozone mean at each monitor in the Northern Kentucky area, as well as the combined statistics for all of the monitors in the Northern Kentucky area. The statistics represent the May through September time period.

Table 3.2.2-1. Northern Kentucky Nonattainment Area Monitor Statistics

Monitor	Modeled Mean (ppb)	Observed Mean (ppb)	Mean Bias (ppb)	Mean Normalized Bias (%)	Mean Normalized Gross Error (%)
NKY Area	66.5	72.8	-6.5	-7.997	13.820
Boone	69.0	72.0	-3.0	-3.656	11.408
Campbell	61.0	74.0	-13.0	-17.252	18.345
Kenton	61.0	72.0	-12.0	-15.158	18.419
Ohio					
Hamilton	68.0	73.0	-6.0	-6.966	14.003
Middletown	68.0	73.0	-5.0	-5.830	11.534
Batavia	66.0	72.0	-7.0	-8.621	13.096
Sycamore	68.0	74.0	-6.0	-6.949	12.359
Colerain	70.0	72.0	-2.0	-1.736	13.252
Taft	67.0	73.0	-5.0	-6.736	13.522
Lebanon	67.0	73.0	-6.0	-7.069	12.262

It is recommended that the combined mean normalized bias fall within ± 5 -15 percent and the combined mean normalized gross error not exceed the 30-35 percent range. For a specific monitor, it is recommended that the mean normalized bias fall within ± 20 percent. From the table above it is demonstrated that the mean bias, mean normalized bias, and mean normalized gross error were all within recommended and accepted ranges.

A slight under prediction of 8-hour ozone was also observed at this more refined level of analysis and was similar to what was seen at the larger state and VISTAS/ASIP region levels. Individual monthly statistics are not presented here due to the very limited number of modeled and observed data pairs at just the three northern Kentucky ozone monitoring sites. Whole season statistics are more representative of how this air quality modeling will be applied in the modeled attainment test discussed in Appendix I. Across the whole season, the Cincinnati-Hamilton OH-KY-IN region as a whole, as well as the individual ozone monitoring sites, had mean normalized bias statistics in the suggested ± 5 -15 percent range and mean normalized gross error statistics in the suggested 30-35 percent range given a 60 ppb threshold.

4.0 CONTROLS APPLIED

Several control measures already in place or being implemented over the next few years will reduce stationary point, highway mobile, and nonroad mobile sources emissions. The Federal and State control measures were modeled for all of the future years and are discussed in the sections below.

4.1 Federal Control Measures

4.1.1 Tier 2 Vehicle Standards

Federal Tier 2 vehicle standards will require all passenger vehicles in a manufacturer's fleet, including light-duty trucks and Sport Utility Vehicles (SUVs), to meet an average standard of 0.07 grams of NO_x per mile. Implementation began in 2004, and should be completely phased in by 2007. The Tier 2 standards will also cover passenger vehicles over 8,500 pounds gross vehicle weight rating (the larger pickup trucks and SUVs), which are not covered by the current Tier 1 regulations. For these vehicles, the standards will be phased in beginning in 2008, with full compliance in 2009. The new standards require vehicles to be 77% to 95% cleaner than those on the road today. The Tier 2 rule also reduced the sulfur content of gasoline to 30 ppm starting in January of 2006. Most gasoline sold in Kentucky prior to January 2006 had a sulfur content of about 300 ppm. Sulfur occurs naturally in gasoline, but interferes with the operation of catalytic converters on vehicles resulting in higher NO_x emissions. Lower-sulfur gasoline is necessary to achieve the Tier 2 vehicle emission standards.

4.1.2 Heavy-Duty Gasoline and Diesel Highway Vehicles Standards

New USEPA standards designed to reduce NO_x and VOC emissions from heavy-duty gasoline and diesel highway vehicles began to take effect in 2004. A second phase of standards and testing procedures, beginning in 2007, will reduce particulate matter from heavy-duty highway engines, and will also reduce highway diesel fuel sulfur content to 15 ppm since the sulfur damages emission control devices. The total program is expected to achieve a 90% reduction in particulate matter (PM) emissions and a 95% reduction in NO_x emissions for these new engines using low sulfur diesel, compared to existing engines using higher-content sulfur diesel.

4.1.3 Large Nonroad Diesel Engines Rule

In May 2004, the USEPA promulgated new rules for large nonroad diesel engines, such as those used in construction, agricultural, and industrial equipment, to be phased in between 2008 and 2014. The nonroad diesel rules also reduce the allowable sulfur in nonroad diesel fuel by over 99%. Nonroad diesel fuel currently averages about 3,400 ppm sulfur. The rule limits nonroad diesel sulfur content to 500 ppm in 2006 and 15 ppm in 2010. The combined engine and fuel rules would reduce NO_x and PM emissions from large nonroad diesel engines by over 90%, compared to current nonroad engines using higher-content sulfur diesel.

4.1.4 Nonroad Spark-Ignition Engines and Recreational Engines Standard

The new standard, effective in July 2003, regulates NO_x, HC and CO for groups of previously unregulated nonroad engines. The new standard will apply to all new engines sold in the United States and imported after these standards begin and will apply to large spark-ignition engines (forklifts and airport ground service equipment), recreational vehicles (off-highway motorcycles and all-terrain-vehicles), and recreational marine diesel engines. The regulation varies based upon the type of engine or vehicle.

The large spark-ignition engines contribute to ozone formation and ambient CO and PM levels in urban areas. Tier 1 of this standard was implemented in 2004 and Tier 2 is scheduled to start in 2007. Like the large spark-ignition, recreational vehicles contribute to ozone formation and ambient CO and PM levels. For the off-highway motorcycles and all-terrain-vehicles, model year 2006, the new exhaust emissions standard was phased-in by 50% and for model years 2007 and later at 100%. Recreational marine diesel engines over 37 kilowatts are used in yachts, cruisers, and other types of pleasure craft. Recreational marine engines contribute to ozone formation and PM levels, especially in marinas. Depending on the size of the engine, the standard began phasing-in in 2006.

When all of the nonroad spark-ignition engines and recreational engines standards are fully implemented, an overall 72% reduction in HC, 80% reduction in NO_x, and 56% reduction in CO emissions are expected by 2020. These controls will help reduce ambient concentrations of ozone, CO, and fine PM.

4.1.5 NO_x SIP Call in Surrounding States

In October 1998, the USEPA made a finding of significant contribution of NO_x emissions from certain states and published a rule that set ozone season NO_x budgets for the purpose of reducing regional transport of ozone (63 FR 57356). This rule, referred to as the NO_x SIP Call, called for ozone season controls to be put on utility and very large industrial boilers, as well as internal combustion engines in 22 states in the Eastern United States. A NO_x emissions budget was set for each state and the states were required to develop rules that would allow the state to meet their budget. A NO_x trading program was established, allowing sources to buy credits to meet their NO_x budget as opposed to actually installing controls. The emission budgets were to be met by May of 2004. Even with the trading program, the amount of ozone season NO_x emissions has decreased significantly in and around Kentucky.

4.1.6 Clean Air Interstate Rule

On May 12, 2005, the USEPA promulgated the “Rule To Reduce Interstate Transport of Fine Particulate Matter and Ozone (Clean Air Interstate Rule); Revisions to Acid Rain Program; Revisions to the NO_x SIP Call”, referred to as CAIR. This rule established the requirement for States to adopt rules limiting the emissions of NO_x and sulfur dioxide (SO₂) and a model rule for the states to use in developing their rules. The purpose of the CAIR is to reduce interstate transport of precursors to fine particulate and ozone.

The CAIR applies to (1) any stationary, fossil-fuel-fired boiler or stationary, fossil-fuel-fired combustion turbine serving at any time, since the start-up of a unit's combustion chamber, a generator with nameplate capacity of more than 25 MWe producing electricity for sale and (2) for a unit that qualifies as a cogeneration unit during the 12-month period starting on the date that the unit first produces electricity and continues to qualify as a cogeneration unit, a cogeneration unit serving at any time a generator with nameplate capacity of more than 25 MWe and supplying in any calendar year more than one-third of the unit's potential electric output capacity or 219,000 MWh, whichever is greater, to any utility power distribution system for sale

This rule provides annual state caps for NO_x and SO₂ in two phases, with the Phase I caps for NO_x and SO₂ starting in 2009 and 2010, respectively. Phase II caps become effective in 2015. The USEPA is allowing the caps to be met through a cap and trade program if a state so chooses to participate in the program. Additionally, Kentucky chose to continue the non-EGUs in the seasonal CAIR program.

4.2 State Control Measures

Kentucky has adopted a number of regulations and legislation to address pollution issues across the State. These include the NO_x SIP Call Rule, and the Open Burning Rule. All of these regulations were modeled in the attainment demonstration. These regulations are summarized below.

4.2.1 NO_x SIP Call Rule

In response to the USEPA's NO_x SIP call, Kentucky adopted rules to control the emissions of NO_x from EGUs and large stationary combustion sources. These rules cover (1) fossil fuel-fired stationary boilers, combustion turbines, and combined cycle systems serving a generator with a nameplate capacity greater than 25 megawatts and selling any amount of electricity, (2) fossil fuel-fired stationary boilers, combustion turbines, and combined cycle systems having a maximum design heat input greater than 250 million British thermal units per hour, and (3) reciprocating stationary internal combustion engines rated at equal or greater than 2400 brake horsepower (3000 brake horsepower for diesel engines and 4400 brake horsepower for dual fuel engines). As part of the NO_x SIP call, the USEPA rules established a NO_x budget for sources in Kentucky and other states.

Kentucky's NO_x SIP Call rule was predicted to reduce summertime NO_x emissions from power plants and other industries by 66% by 2006. In August 2001, the Kentucky Natural Resources and Environmental Protection Cabinet adopted rules requiring the reductions.

4.2.3 Open Burning Bans

Kentucky revised the open burning regulation to prohibit most types of open burning in moderate ozone nonattainment areas within Kentucky during the period of May- September with ozone is most likely. This requirement continues in the Northern Kentucky area.

4.2.4 Clean Air Interstate Rule

In response to the USEPA's CAIR, the KYDAQ developed rules to implement CAIR. Under the rule, Kentucky has caps as follows:

- Annual NO_x: 83,205 tons for 2009-2014 and
69,337 tons for 2015 and each year thereafter;
- Ozone season NO_x: 36,109 tons for 2009-2014 and
30,651 tons for 2015 and each year thereafter;
- Annual SO₂: 188,773 tons for 2010-2014 and
132,141 tons for 2015 and each year thereafter.

The State's NO_x allocations have been distributed based on allocation methodologies in 401 KAR 52:210 and 220. The USEPA will determine the SO₂ allocations, which are based on the acid rain program. For the most part the rules follow the USEPA's model rule. This rule does not preclude the DAQ from adopting additional emission reduction requirements for covered sources if necessary to attain or maintain an ambient air quality standard.

The KYDAQ CAIR regulations became effective February 2, 2007.

5.0 ATTAINMENT DEMONSTRATION

5.1 Attainment Test Introduction

The modeled attainment test is the practice of using air quality modeling results for baseline and future years to determine if an area is expected to attain the NAAQS. For the 8-hour ozone NAAQS, the baseline and future model estimates are used in a “relative” rather than “absolute” sense. Specifically, the ratio of the air quality model’s future to current predictions is calculated at each ozone monitoring site. These monitoring site-specific ratios are called relative response factors (RRFs). Future ozone design values (DVF) are then estimated at each monitor by multiplying the monitor-specific baseline ozone design value (DVB) by the modeled RRF for each monitor. If all of the predicted monitor-specific DVFs in a given area are less than or equal to 0.084 ppm, the attainment test is passed and the area is said to demonstrate attainment. Equation 5.1-1 presents the modeled attainment test, applied at monitoring site “x” as described in Section 4.0 of the USEPA’s *Attainment Guidance*.

$$(\text{DVF}) = (\text{RRF}) \times (\text{DVB}) \quad \text{Equation 5.1-1}$$

Where (DVB) = the baseline design value monitored at site "x", ppm

= the average (of the three) design value periods which include the baseline inventory year (i.e. the average of the 2000-2002, 2001-2003, and 2002-2004 design vales periods for the 2002 baseline inventory year).

(RRF) = the ratio of the future 8-hr daily maximum concentration predicted "nearby" a monitor (averaged over each day of the episode) to the current 8-hr daily maximum concentration predicted "nearby" the monitor (averaged over each day of the episode).

(DVF) = the estimated future design value, ppm.

It is important to consider an array of cells “nearby” a monitor rather than focusing on the individual cell containing the monitor. This allows for variations in the model performance where the peak ozone may not occur in the grid cell that contains the monitor but rather nearby the monitor.

The RRF is calculated by taking the ratio of the future year modeling 8-hour ozone daily maximum to the current year modeling 8-hour ozone daily maximum “near” the monitor averaged over all of the episode days (Equations 5.1-2).

$$\text{RRF} = \frac{\text{mean future yr. 8-hr daily max “near” monitor “x”}}{\text{mean current yr. 8-hr daily max “near” monitor “x”}} \quad \text{Equation 5.1-2}$$

The DVC, for purposes of the modeled attainment test, is defined in the USEPA’s *Attainment Guidance* the average of the three design value periods that straddle the baseline inventory year (e.g., the average of the 2000-2002, 2001-2003, and 2002-2004 design value periods for a 2002 baseline inventory year).

5.2 Attainment Test Results

As stated above, the attainment test is not based on absolute modeling results but rather relative reductions of ozone and is only applied at the monitors. However, reviewing the modeling results of how the predicted ozone decreases in the future years and how wide spread the reductions are plays an important role for the State in determining if additional controls should be considered. The modeling results for each day used in the RRF calculations are available in Appendix I.

The USEPA’s *Attainment Guidance* states that future design values (DVs) that fall below 0.082 ppm demonstrate attainment and that little weight of evidence is needed. For monitors with DVs between 0.082 ppm and 0.087 ppm, weight of evidence must be submitted that supports a demonstration of attainment. DVs greater than 0.087 ppm fail the attainment test.

Table 5.2-1 lists the attainment test results for the Cincinnati-Hamilton OH-KY-IN 8-hour Ozone Nonattainment Area. The first column is the monitoring site, followed by the base year design value discussed in Section 5.1. The next series of columns are the calculated RRF and the resulting DV for the attainment year 2009. Monitors with DVs that fall in the additional weight of evidence requirement are bolded.

Table 5.2-1 Attainment Test Results

County	Monitor I.D.	DVB (ppm) 5-year weighted 2000-2004	2009	
			RRF	DVF (ppm)
Boone	21-015-0003	0.0841	0.870	0.072
Campbell	21-037-0003*	0.0912	0.908	0.082
Kenton	21-117-0007	0.0856	0.908	0.077
Butler	39-017-0004	0.0901	0.905	0.081
Butler	39-017-1004	0.0901	0.897	0.078
Clermont	39-025-0022	0.0896	0.907	0.081
Hamilton	39-061-0006	0.0910	0.898	0.081
Hamilton	39-061-0010	0.0863	0.905	0.077
Hamilton	39-061-0040	0.0864	0.918	0.078
Warren	39-165-0006**	0.0901	0.878	0.079
Warren	39-165-0007	0.0907	0.878	0.079

* This monitor was discontinued after the 2005 ozone season.

**This monitor was discontinued after the 2003 ozone season and became 39-165-0007 in 2004.

5.3 Supporting Weight of Evidence

As part of the weight of evidence determination, the following analyses will be evaluated: development of a 2008 emissions inventory from the 2009 inventory, alternative DVFs calculations, air quality modeling results from other studies, and observed air quality trends. The weight of evidence determination is a supplement to the modeled attainment test and further supports that the area will attain the NAAQS for 8-hour ozone by June 15, 2008.

The KYDAQ believes that the weight of evidence provided in the sections below is strong evidence that the Cincinnati-Hamilton OH-KY-IN 8-hour Ozone nonattainment area will attain the 8-hour ozone NAAQS by 2008.

5.3.1 Development of 2009 emissions inventory (see Appendix I)

By letter dated March 27, 2006, a request was made to U.S. EPA to allow the use of 2009 modeling results for the development of attainment demonstrations. This was approved in an e-mail dated May 9, 2006 (see Appendix A). Emissions of VOC, CO, and NO_x were developed for 2008 using the 2009 emissions inventory utilized by VISTAS for the modeling. The methodology for this development is as follows:

Daily 2009 emissions were divided by annual 2009 emissions to come up with a ratio of daily to annual. This factor was then applied to the annual 2008 emissions to develop daily 2008 emissions. The formula is:

(Daily 2009/ annual 2009) * Annual 2008 = Daily 2008.

Table 2.1-1 located at the end of Appendix I documents these calculations and their results.

Table 2.1-2 located at the end of Appendix I shows a comparison between the 2008 and 2009 emissions, the percentage difference and the absolute difference. For the entire nonattainment area, the percentage differences for VOC and CO are below three percent (3%).

The percentage difference for NO_x for the entire nonattainment area is approximately twenty-nine percent (29%). This much higher percentage difference is attributable to the onset of the CAIR reductions as well as the earlier reductions due to the NO_x SIP Call. In addition, the difference in NO_x emissions is not relevant since U.S. EPA has approved the area as exempted from the NO_x requirements as specified in Section 182(f). In the *Federal Register* direct final rule dated February 12, 2002, page 6413, (see Appendix J) the U. S. EPA stated that the area was exempt from section 182(f) NO_x requirements. This exemption means that the Administrator of the U.S.EPA determined that NO_x reductions would not contribute to attainment.

5.3.2 Alternative DVB Calculation

The USEPA recommends calculating the DVB by averaging the three design value periods that straddle the baseline inventory year. This methodology results in a center weighting of annual 4th highest ozone concentrations around the baseline inventory year because the three design value periods averaged contain overlapping data. A weighted DVB can be significantly affected by an abnormally hot/dry or cool/wet year, if the year happens to be the center weighted year.

To minimize potential impacts of any abnormal meteorological conditions while still considering ozone conditions across a 5-year span, the KYDAQ prefers an alternative DVB calculation that does not weight any of the years more than another, but is the straight average of annual 4th highest ozone concentrations for the 5-year span centered on the baseline inventory year.

The KYDAQ preferred DVB calculation is applied to the remainder of the modeled attainment test equations and the resulting DVFs are shown in Table 5.3.2-1 at each monitoring site in the Cincinnati-Hamilton OH-KY-IN 8-hour Ozone Nonattainment Area .

Table 5.3.2-1 5-Year Average Alternative Attainment Test Results for 2009

County	Monitor I.D.	DVB 5-Year Straight Average 2000-2004 (ppm)	RRF	DVF (ppm)
Boone	21-015-0003	0.0816	0.870	0.071
Campbell	21-037-0003*	0.0888	0.908	0.080
Kenton	21-117-0007	0.0834	0.908	0.075
Butler	39-017-0004	0.0868	0.905	0.078
Butler	39-017-1004	0.0856	0.897	0.076
Clermont	39-025-0022	0.0874	0.907	0.079
Hamilton	39-061-0006	0.0876	0.898	0.078
Hamilton	39-061-0010	0.0836	0.905	0.075
Hamilton	39-061-0040	0.0844	0.918	0.077
Warren	39-165-0006**	0.0880	0.878	0.077
Warren	39-165-0007	0.0880	0.878	0.077

* This monitor was discontinued after the 2005 ozone season.

**This monitor was discontinued after the 2003 ozone season and became 0007 in 2004.

The alternative DVFs are slightly lower at each monitoring site compared to the attainment test DVFs. These differences were expected as 2002 was an abnormally hot and dry year throughout the Southeast resulting in ozone concentrations that were higher than normal and that were much higher than in the surrounding years of 2000, 2001, 2003, and 2004. Thus, the recommended DVB calculation weighted these abnormally high air quality conditions several times more than in the KYDAQ alternative DVB calculations. The KYDAQ firmly believes that the straight five-year average approach to the DVB calculation is more appropriate and minimizes dramatic fluctuations in meteorological and air quality conditions from year to year. Using this approach all monitors fall below the 0.082 trigger for further additional weight of evidence determination.

Another air quality modeling exercise that contained results for the Cincinnati-Hamilton OH-KY-IN 8-hour Ozone Nonattainment Area nonattainment area is the USEPA's modeling for the Clean Air Interstate Rule (CAIR). The Technical Support Document for the final CAIR, March 2005, provided modeling results with and without the implementation for the CAIR. These modeling results are listed in the table below.

Table 5.3.2-2 Cincinnati-Hamilton OH-KY-IN 8-hour Ozone Nonattainment Area DVFs based on the USEPA's CAIR Modeling

County	DVB (ppb)	DVF (ppb)	
		2010 Base	2010 CAIR
Boone	85.3	73.1	73.1
Campbell	92.5	81.6	81.5
Kenton	86.3	75.7	75.6
Butler	89.0	78.2	78.0
Clermont	90.0	78.1	78.0
Clinton	95.7	81.7	81.4
Hamilton	89.3	78.8	78.6
Warren	92.0	80.2	80.0

The USEPA's modeling results predicts that the Cincinnati-Hamilton OH-KY-IN area should be below the 8-hour ozone standard by 2010. Although this is two years later than the attainment year for the Cincinnati-Hamilton OH-KY-IN 8 area, the USEPA's 2010 CAIR DVFs are significantly lower than the 8-hour ozone standard, and supports weight of evidence that the Cincinnati-Hamilton OH-KY-IN area will attain the 8-hour ozone standard by its attainment year of 2008.

5.3.3 Air Quality Trends and Additional Reductions in Emissions

Since the 8-hour ozone designation for the Cincinnati-Hamilton OH-KY-IN area, the 8-hour ozone design values have improved significantly. The 2001-2003 design value period had values as high as 0.093 ppm and one of the Kentucky monitors in the area was violating the NAAQS. Each year since, the design values have decreased and/or the number of violating monitors in the region has decreased. With the latest design value period, 2004-2006, the highest violating monitor has a value of 88 ppb and there are only three monitors that exceed the NAAQS, none of which are in Kentucky. (See Table 5.3.3-1)

Table 5.3.3-1 Design Values (ppm) for the Kentucky Monitors in the Cincinnati-Hamilton OH-KY-IN 8-hour Ozone Nonattainment Area

County	Monitor I.D.	2001-2003	2002-2004	2003-2005	2004-2006
Boone	21-015-0003	0.085	0.080	0.076	0.074
Campbell	21-037-0003*	0.091	0.087	0.083	*
Kenton	21-117-0007	0.085	0.082	0.078	0.077
Butler	39-017-0004	0.092	0.089	0.085	0.080
Bulter	39-017-1004	0.089	0.085	0.082	0.079
Clermont	39-025-0022	0.090	0.088	0.083	0.078
Hamilton	39-061-0006	0.093	0.089	0.086	0.082
Hamilton	39-061-0010	0.087	0.086	0.082	0.080
Hamilton	39-061-0040	0.087	0.084	0.082	0.080
Warren	39-165-0006**	0.091	0.089	**	**
Warren	39-165-0007	0.091	0.089	0.087	0.086

* This monitor was discontinued after the 2005 ozone season.

**This monitor was discontinued after the 2003 ozone season and became 39-165-0007 in 2004.

There are still significant nitrogen oxides (NO_x) emission reductions that are expected between now and the attainment year. Additional reductions in NO_x will occur from the industrial sector and from EGUs with the implementation of CAIR. Also, the KYDAQ has estimated that there will be approximately 7.4 tons per day of NO_x emissions reduced from the mobile sector between the base year of 2002 and the attainment year of 2008. These reductions are the result of Federal motor vehicle and equipment standards for both highway vehicles and off-road equipment.

5.4 Data Access

The modeling input and output files are very large and it would not be reasonable to submit all of these files with the SIP attainment demonstration. These include all files used to process the emissions, meteorology and air quality models and any other files used to develop the modeling. To request access to these files please contact the Division for Air Quality, Program Planning and Administration Branch Manager at 502.573.3382.

6.0 OTHER CLEAN AIR ACT REQUIREMENTS

Section 172(c) of the CAA, as amended, contain the requirements for ozone nonattainment areas. As a subpart 1 basic ozone nonattainment area, the Cincinnati-Hamilton OH-KY-IN area must meet the requirements for a basic area, as contained in Section 172(c). These requirements are listed below and are discussed in more detail in the following chapter.

Section 172(c) Nonattainment Plan Provisions

- (1) Reasonable available control measures (RACM)
- (2) Reasonable further progress (RFP)
- (3) Actual emissions inventory and periodic emissions inventory
- (4) New source review (NSR)
- (5) Permit requirements for new and modified sources
- (6) Other measures as may be necessary to provide attainment by specified attainment date
- (7) Compliance with Section 110(a)(2)
- (8) Contingency measures

6.1 RACT/RACM Requirements

Section 172(c)(1) of the CAA requires SIPs to provide for the implementation of all reasonably available control technology (RACT) and reasonably available control measures (RACM) to demonstrate attainment as expeditiously as practicable. Kentucky Administrative Regulation 401 KAR 50:012, Section 1 (2) requires that all major air contaminant sources shall as a minimum apply control procedures that are reasonable, available, and practical.

6.2 Actual Emissions Inventory

In Northern Kentucky, all sources are inventoried on an annual basis. In addition, in 2002 U.S. EPA approved the redesignation of the Kentucky portion of the Cincinnati-Hamilton 1-Hour Ozone nonattainment area. Contained in this redesignation was a maintenance plan with projected years emissions. The approval of this maintenance plan and the projected 2002 emissions inventory by U.S. EPA meets the requirements of Section 172(c)(3). The years projected in the maintenance plan were 2002, 2005, 2008, and 2010. The projected inventory is lower than the modeling inventory developed by the VISTAS/ASIP contractors for 2008. That the modeling shows attainment even with the higher inventory numbers clearly demonstrates that the area will be in attainment in 2008.

6.3 Periodic Emissions Inventory

Section 172(c)(3) requires periodic inventory submittals. KYDAQ plans to meet this requirement through the CERR submittal.

6.4 Other Measures

Section 172(c)(6) requires the nonattainment SIPs to include enforceable limitation and other control measures, along with schedules for compliance as needed to demonstrate attainment. Section 4.0 of this document discusses in detail the Federal and State measures that are necessary for attainment.

6.5 Compliance with Section 110(a)(2)

Section 172(c)(7) requires nonattainment SIPs to meet the applicable provisions of Section 110(a)(2). The KYDAQ has reviewed the requirements of Section 110(a)(2) and has concluded that the prior rule submittals, along with this attainment demonstration plan address the relevant requirements.

6.6 Equivalent Techniques

The KYDAQ believes that the procedures for modeling, emissions inventory and planning follow the USEPA guidance and is not requesting approval for equivalent techniques, as envisioned under Section 172(c)(8).

6.7 Contingency Measures

Section 172(c)(9) requires that the nonattainment SIPs contain specific measures that would take effect upon a State's failure to attain the ozone standard in a given area, without further action by the State or the USEPA. The contingency plan consists of Federal measures.

Mobile Requirements

The Federal measures result from the fleet turnover of the light and heavy-duty engine standards from the on-road mobile sector and the non-road engine standards. These measures are already adopted and the fleet turnover will occur without further action by either the State or the USEPA.

Aerosol Coatings, Architectural and Industrial Maintenance Coatings, and Commercial/Consumer Products

In 1998 the U.S. EPA offered a guidance document promulgating federal regulations to reduce the VOC emissions from the application of Architectural and Industrial Maintenance Coatings (e.g. traffic paints and coatings for bridges), Auto Body Refinishing, and Commercial Consumer Products. Kentucky documented these reductions in the 15% reduction plan and subsequent

redesignation request for the Northern Kentucky area. At that time a 20% reduction was allowed. On May 30, 2007, the EPA published a memorandum to provide guidance concerning credit that States can take for reductions associated with three Federal rules being promulgated this calendar year under authority of section 183 (e) of the Clean Air Act (see Appendix K). These rules will establish or amend VOC content limits for (1) aerosol coatings (new rule), architectural and industrial maintenance (AIM) coatings (amendments), and (3) household and institutional consumer products (amendments). EPA estimates that the amended Federal AIM rule will achieve a reduction of 31% from the post-1998 Federal rule baseline. The amount of reduction from the Commercial/Consumer Product emission reduction credit was calculated at 29%. The compliance date for the three Federal rules will be January 1, 2009. Table 6.7 shows the additional reductions in VOC emissions due to these new rules.

Table 6.7 2002 Area Source Emission Reductions, Based on Federal Guidance

Boone	2002 VOC w/o red.	VOC % red.	2002 VOC red.	2002 VOC w/red.	New VOC % red.	New 2002 VOC red.	New 2002 VOC w/red.
Com./Con.Prod. Use	0.75	20%	0.15	0.60	29%	0.17	0.43
Architect. Surf. Coat.	0.71	20%	0.14	0.57	31%	0.18	0.39
Traffic Markings	0.08	20%	0.02	0.06	31%	0.02	0.04
County Totals				1.23			0.86
Campbell	2002 VOC w/o red.	VOC % red.	2002 VOC red.	2002 VOC w/red.	New VOC % red.	New 2002 VOC red.	New 2002 VOC w/red.
Com./Con.Prod. Use	0.77	20%	0.15	0.62	29%	0.18	0.44
Architect. Surf. Coat.	0.73	20%	0.15	0.58	31%	0.18	0.40
Traffic Markings	0.08	20%	0.02	0.06	31%	0.02	0.04
County Totals				1.26			0.88
Kenton	2002 VOC w/o red.	VOC % red.	2002 VOC red.	2002 VOC w/red.	New VOC % red.	New 2002 VOC red.	New 2002 VOC w/red.
Com./Con.Prod. Use	1.28	20%	0.26	1.02	29%	0.30	0.72
Architect. Surf. Coat.	1.22	20%	0.24	0.98	31%	0.30	0.68
Traffic Markings	0.14	20%	0.03	0.11	31%	0.03	0.08
County Totals				2.11			1.48
Kentucky Totals				4.60			3.22

7.0 MOTOR VEHICLE EMISSION BUDGETS

7.1 Transportation Conformity

The purpose of transportation conformity is to ensure that Federal transportation actions occurring in nonattainment and maintenance areas do not hinder the area from attaining and maintaining the 8-hour ozone standard. This means that the level of emissions estimated by the NCDOT or the metropolitan planning organizations for the Transportation Implementation Plan (TIP) and Long Range Transportation Plan must not exceed the motor vehicle emission budgets (MVEBs) as defined in this attainment demonstration.

7.2 Motor Vehicle Emission Budgets

As part of the consultation process on setting MVEBs, the KYDAQ participated in several conference calls with all of the transportation partners. It was decided to have sub-area budgets for the Kentucky portion of the nonattainment area and a combined sub-area budget for the Indiana and Ohio portion of the nonattainment area. The MVEBs will be set for the attainment year 2008. By the time the MVEBs are approved by the USEPA, the next transportation conformity regional emissions analysis should be for years 2008 and beyond. Therefore, MVEBs will not be set for the baseline year 2002.

Although the emissions are usually expressed in terms of tons per day, the MVEBs will be set in terms of kilograms (kg) per day. The reason for the change is because the MOBILE model generates the emissions factors in grams per mile. In past conformity exercises, there have been some issues with conversion to tons per day, as well as concerns with how the MVEBs were rounded to the hundredth place. Setting MVEBs in kilograms per day will avoid these issues in future conformity determinations.

The table below shows the Kentucky counties with their highway mobile VOC and NOx emissions expressed in tons per day for 2008. Although the mobile numbers were calculated as in the latest planning assumptions furnished by the MPO, the numbers created from the modeling are slightly higher than those calculated by OKI.

Table 7.2-1 Highway Mobile Source Emissions for the Kentucky portion of the Cincinnati-Hamilton OH-KY-IN 8-Hour Nonattainment Area

County	2008 Tons/day	
	VOC	NO _x
Boone	9.44	11.44
Campbell	5.79	5.64
Kenton	12.34	10.94
Total	27.57	28.02

The KYDAQ will set MVEB, for transportation conformity purposes, for the Kentucky portion of the nonattainment area for 2008. Upon the USEPA's affirmative adequacy finding for these sub-area MVEBs, these MVEBs will become the applicable MVEBs.

8.0 Public Notice

A public hearing to take comments on this Attainment Demonstration is scheduled for 1:30 p.m. on July 24, 2007, at the offices of the Northern Kentucky Area Development District located at 22 Spiral Drive, Florence, Kentucky. A copy of the public hearing notice is in Appendix L.

After the public hearing, Appendix L of the final submittal will contain the comments and the statement of consideration for this submittal.